Research Problem Review 74-4

LEVEL II

MAN-MACHINE EVALUATION OF THE M60A2 TANK SYSTEM

FINAL DRAFT

FORT HOOD FIELD UNIT

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(6) MAN-MACHINE EVALUATION OF THE M60A2 TANK SYSTEM,

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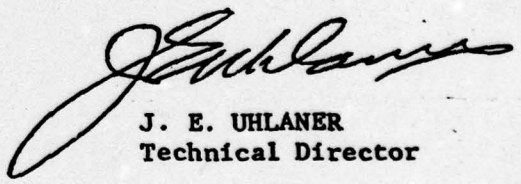
FOREWORD

The Fort Hood Field Unit of the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) provides human factors field experimentation support to Headquarters, MASSTER--Modern Army Selected Systems Test Evaluation & Review. Equipment, doctrine, and concepts are tested at MASSTER within the context of total systems in an operational environment, usually for the first time; the total system includes the soldier as the human factor component. Therefore, all MASSTER tests involve evaluations of the interface between the human being and the other system components, and as such require the support of personnel trained in behavioral science. A primary role of these personnel is to determine whether specific test results are the function of characteristics of the item being tested or of characteristics of the men using that item.

In the specific research reported in this paper, a human factors evaluation of the M60A2 tank system was conducted in conjunction with an Intensified Confirmatory Troop Test of the system, in order to identify man/machine interface problems of the M60A2 tank and to identify ways to reduce or eliminate such problems. ARI research in this area is conducted as an in-house effort augmented by research contracts with organizations with unique capabilities for human factors research. The present task was done jointly by personnel from the Essex Corporation and the Fort Hood ARI Field Unit, and is responsive to the special requirements of MASSTER as well as the objectives of RDTE Project 2Q162106A721, FY 1974 Work Program.



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MAN-MACHINE EVALUATION OF THE M60A2 TANK SYSTEM

BRIEF

Requirement:

The research requirement specified that a human factors evaluation of the M60A2 tank system be conducted in conjunction with an Intensified Confirmatory Troop Test of the system.

The evaluation was directed at ~~six specific areas~~:

- Personnel selection,
- Training,
- Operational and Maintenance Procedures,
- Manuals and publications,
- Equipment design and
- Communications.

The objectives were to:

- identify human factors (man/machine interface) problems of the M60A2 tank systems and
- formulate recommendations for actions that would minimize the number and/or impact of these problems on system efficiency.

Procedure:

As a prelude to the introduction of the M60A2 tank into the weapons inventory of the US Army, Europe, an Intensified Confirmatory Troop Test (ICTT) was conducted under the auspices of Hq. MASSTER, Fort Hood, Texas. The human factors portion of the evaluation was conducted by Essex Corporation under contract to the Army Research Institute.

The test cycle consisted of evaluating the tank system during three phases:

- Phase I - Crew and maintenance personnel training
- Phase II - Gunnery training
- Phase III - Field training exercises culminating in the completion of a battalion Army Training Test (ATT)

The human factors evaluation team participated in all phases of the ICTT and worked in close coordination with other tank system evaluators and test personnel. Data collection procedures consisted of:

- Observation of man/machine interaction by human factors analysts
- Measurement of quantifiable factors underlying identified problems, e.g., work station envelope dimensions
- Administration of questionnaires
- Conduct of interviews

Due to the non-comparative nature of collected data, descriptive (rather than inferential) statistical techniques were employed. A list of findings and recommendations for solutions to human factors problems were formulated by a joint team composed of armored officers and human factors psychologists. Their findings and recommendations are based upon the team's interpretation and analysis of the study data.

Principal Findings:

- Personnel Selection - Loader entrance skills should be reevaluated.

- Crew Training - The training program requires standardization and organization. Course content coverage needs to be expanded. Training methods, instructor skills, and tests need to be standardized.

- Maintenance Training - Only minor problems were identified and these were attributable primarily to deficiencies in manuals, lack of sufficient spare parts and lack of sufficient instructor personnel.

- Operating Procedures - Certain procedures need to be reexamined, formalized, standardized and disseminated to a greater degree.

- Manuals and Publications - Both operations and maintenance manuals are deficient, which impacts on mission accomplishment and system availability.

- Equipment Design - Duty stations are cramped, uncomfortable, and in some respects, hazardous. (Recommended solutions for specific design problems for each duty station have been formulated only for problems which directly impact on crew safety.)

- Communications - Selected communications equipment needs modification. Communications procedures should be changed for optimum efficiency.

Utilization of Findings:

The incorporation of recommended specific changes to procedures, policies, and system design will improve M60A2 training effectiveness, will reduce existing safety hazards, and will improve the overall effectiveness of the M60A2 tank system.

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1.0 INTRODUCTION

As a prelude to the introduction of the M60A2 tank into the weapons inventory of the U. S. Army, Europe, an Intensified Confirmatory Troop Test (ICTT) was conducted by 1st Battalion 67th Armor (1/67 Bn), 2nd Armored Div. at Ft.Hood, Tx. This ICTT was intended to facilitate for the recipient European units the transition from the M60A1 to the M60A2 tank system. The ICTT was conducted by issuing the M60A2 tank to the 1/67 Bn which was at a training level of Combat Ready in the M60A1 tank. The training and transition in M60A2 tanks from Non-Combat Ready to Combat Ready was monitored and evaluated by personnel of the Ground Combat Directorate of Modern Army Selected System Test, Evaluation and Review (MASSTER) of Ft. Hood, Texas.

1.1 Test Overview

The test was conducted through three distinct calendar and unit activity periods identified as Phases I, II, and III.

1. Phase I consisted of crew and maintenance personnel training on the M60A2 tank. The phase began with individual 1/67 Bn cadre training at Ft. Knox, Kentucky, for the gunners and tank commanders. The MASSTER military evaluators also attended the Ft. Knox training which was modified for them by the elimination of most of the live firing portion of the course. Maintenance training was held at Aberdeen Proving Ground,

Maryland, for limited numbers of 1/67 Bn personnel in Military Occupational Specialties (MOS) 41C (Fire Control Repairman) on the M60A2 Fire Control System course of instruction; and MOS 45K (Tank Turret Repairman) on the M60A2 Turret and Armament Course. Personnel from Ft. Knox conducted training at Ft. Hood in maintenance of the Closed Breech Scavenger System (CBSS) for MOS 63C, Tracked Vehicle Mechanics.

Upon completion of the tank commanders' and gunners' cadre training at Ft. Knox, these 1/67 Bn personnel returned to Ft. Hood. There they conducted individual training consisting of classroom and practical exercises for the tank drivers and loaders. This training was preliminary to the field training exercises.

The field training exercises were conducted to prepare the tank platoons to take their formal Platoon Army Training Test (ATT). The Platoon ATT was the first formal evaluation step to becoming M60A2 Combat Ready. As each platoon completed the ATT, they transitioned to field training for the Company ATT. In the Company ATT the platoons demonstrated the ability to operate effectively as a company sized unit for all required types of activity. The completion of all formal Company ATT's terminated Phase I.

2. Phase II (Gunnery) comprised the span of activity required to train each crew of the battalion in gunnery operations to the point of formal live fire gunnery qualification. This necessitated periods of individual and crew training in duties and gunnery procedures by means of the dry fire technique. The dry fire period preceded deployment to the firing range. During Phase II activity at the firing ranges each crew proceeded through the eight formal tables required to complete

Combat Ready gunnery qualification. Successful completion by all crews of the gunnery qualification course (Tank Table VIII) signified the completion of Phase II.

3. Phase III activities involved the completion of the final step to qualify the 1/67 Bn as Combat Ready. This phase consisted of field training exercises where the three companies interacted as a battalion sized unit. The training terminated in the completion of a formal Battalion ATT. Completion of the Battalion ATT was the end of Phase III with the 1/67 Bn officially designated as M60A2 Combat Ready.

1.2 Human Factors Evaluation of the M60A2 Tank System

1.2.1 Objective

The technical objective of this effort was to evaluate the man/machine interface within the M60A2 Tank System.

1.2.2 Scope

Man/machine interface (human factors) problems with the operation and maintenance of the M60A2 tank system were evaluated in a field operation environment with the 1/67 Bn, 2nd Armored Division. This evaluation was performed concurrently with and in close coordination with the M60A2 ICTT. Human factors problem areas were to be identified in the following specific areas:

- Personnel Selection
- Training
- Operational and Maintenance Procedures

- Manuals and Publications
- Equipment Design
- Communications

When it was determined that changes were required in the above areas, recommendations for change were to be formulated. An exception to this procedure involved equipment design problems, where no recommendation for redesign was to be presented except in those cases where the design deficiency directly impacts crew safety.

1.2.3 Human Factors Evaluation Guidelines

Guidelines for performance of the human factors evaluations included the following:

- The human factors evaluators participated in all aspects of the ICTT which could provide information on human factors problem areas, including field exercises, special tests, and classroom instruction.
- Participation by human factors evaluators was always on a non-interference basis. Non-interference meant that the evaluators did not intrude or interfere with on-going crew or maintenance activities.
- Human factors evaluators worked in close coordination and cooperation with other tank system evaluators, to ensure that man-machine problems were viewed in the system context, and to provide other evaluators with current findings and implications of the man-machine evaluations.

- Close liaison was maintained with other evaluation personnel by human factors evaluators to promote maximum data use and minimize redundancy of questionnaires administered. All data acquired was available to all evaluators. The results of these questionnaires were reviewed for data of use to the human factors evaluation at the close of each test phase.
- The human factors evaluation involved the area of doctrine of employment and tactics only to the degree that requirements in this area had an impact on, or are affected by crew performance and safety.

2.0 METHODOLOGY

The essential human factors evaluation activities conducted during this three phase program include data collection, data analysis and integration, and report generation and publication. The data collection procedures consisted of:

Identification: Of problem areas through the application of standard human factors analytical techniques

Observation: Of training and of tank crew performance

Measurement: Of quantifiable factors underlying identified problems, such as work station envelope dimensions, noise environment, etc.

Questionnaires: To be administered to participating tank crews at the conclusion of each phase

Interviews: With tank crew members and organization personnel (company commanders, platoon leaders, etc.)

Data collected during Phase I was directed toward the evaluation of M60A2 tank crew training, and toward evaluation of the tank system man/machine interface including design factors, procedures, communications, and documentation. Data collected during Phase II was tailored to the evaluation of gunnery training and crew performance as well as continuing the evaluation of tank design, procedures, communications, and documentation. During Phase III data included evaluation of maneuvering performance, both single tank and tank unit, and completion of the evaluation of tank design, procedures, communications, and documentation.

Data analysis and integration activities generally involved:

- data validity checks
- identification of potential problem areas
- verification of problems
- determination of problem criticality for crew performance and safety
- identification of causal factors and contributing conditions
- development of recommended solutions to problems

The principal methodological problem area was the limitation placed on Essex personnel in actually riding in or on tanks to observe operations at firsthand. For safety reasons, no one is allowed on the exterior of a tank when it is in motion. Due to severe workspace constraints, there is simply no room in a fully manned M60A2 tank for an evaluator to observe crew operations and performance in an unobstrusive manner.

A description of human factors evaluation activities in each of the ICTT phases is presented below:

2.1 Phase I Training

In conjunction with the evaluation activities specific to each Test Program phase, a human factors analysis effort was initiated in Phase I and carried through the remaining two phases of the program. This effort essentially involved the application of specific analytic methods and the integration of information resulting from Phase specific evaluations and prior analyses. The specific analyses conducted during this effort, and the activity involved in developing evaluation criteria, are presented below:

2.1.1 Task-Timeline Analysis

Based on reviews of documents, walk throughs of procedures, and discussions with personnel familiar with tank operation, a task analysis - time line was generated for each significant operational mode (Appendix A). These modes included:

- pre/post operational check
- carry mode operation
- conduct of fire-conventional-all modes
- conduct of fire-missile engagement
- conduct of fire-COAX engagement
- conduct of fire-.50 caliber engagement

The analysis identified the tasks and task sequences for individual crewmen as well as interactions among crewmembers. The results of this analysis provided the operational requirements which served as the baseline for the remaining analyses.

2.1.2 Operability Analysis:

The assessment of M60A2 tank system operability involved:

- design for operability - specifically design aspects of the man/machine interface, including controls, displays, optical aids, workspace, console layout and arrangement, communications equipment, seats and restraints, handholds and footholds, hatch dimensions, etc.
- adequacy of operational procedures and operational sequences
- adequacy of crew workloads - both physical and mental
- adequacy of crew skills and skill levels

2.1.3 Safety Analysis

An assessment of the safety of M60A2 equipment and procedures was performed in conjunction with the operability analysis. The data acquisition methods used in this analysis were the same as those identified for the operability analysis. The safety analysis stressed identification of potential hazards, including:

- electrical hazards - electrical shock, etc.
- mechanical hazards - moving parts
- structural hazards - sharp edges, corners, etc.
- atmospheric hazards - toxic fumes, etc.
- noise hazards

2.1.4 Maintainability Analysis

The essential activities in this analysis included determination of equipment accessibility for removal/replacement, and problem areas encountered in the conduct of such maintenance activities as re-supply and refurbishment, cleaning, inspection, fastener or connector activation and verification, actual removal and replacement of components and modules, and use of tools and test sets.

2.1.5 Documentation Analysis

Tank system manuals and documents were reviewed in terms of their readability, content, and physical characteristics.

2.2 Phase II - Gunnery

The primary activities performed during this phase included the conduct of the human factors evaluation of gunnery training and crew performance, the continuation of human factors analyses as described in Section 2.1, and the analysis and interpretation of data obtained in Phase I.

As the ICTT progressed, it became apparent that some special studies were required. These studies included an evaluation of the Tank Commander (TC) seat assembly, a study of the effects of a full-combat ammunition load on crew performance and on the tank system itself, and a study on driver safety problems.

The TC seat assembly study was performed by direct observation with stop watches and schematic diagrams used as aids in data collection.

During the full-combat load test a human factors evaluator participated as a crewmember, making direct observation and conducting interviews with crewmen of the other tanks used in the test.

For the driver safety test, a study of the problem and review of potential solutions were performed. An approach was selected and an empirical evaluation was made through the fabrication of a mock-up to determine feasibility.

These three studies are reported in detail in Appendices C,D, and E of this report. The findings were submitted to the appropriate authority for review and possible implementation.

2.2.1 Tank Gunnery Evaluation

The activities performed in the Human Factors evaluation during Phase II include the following:

Preliminary Gunnery Evaluation

During the initial segment of the phase, Essex personnel observed gunnery training exercises and the conduct of the Preliminary Gunner's Exam, and conducted interviews with trainees and evaluation personnel. The factors of particular interest during this segment include the following:

1) Adequacy of instruction, training aids, course content, etc. as conducted in the Training Phase.

2) Adequacy of equipment design, information flow, communications, procedures, and operational sequences as they affect performance and safety of individual crewmen during gunnery exercises.

3) Adequacy of the above items as they affect integrated performance of the entire tank crew.

Tank Firing

The factors of concern for this phase included:

1) Adequacy of gunnery controls and displays while stationary and while moving.

2) Adequacy of procedures and operational sequences.

3) Adequacy of communications techniques.

4) Adequacy of information flow, within the tank, in terms of target information, gun status, feedback, and decision information.

Phase II Questionnaire

The human factors gunnery questionnaire developed by Essex and administered to all tank crewmen at the end of Phase II is presented in Appendix B.

2.2.2 Continuation and Update of HF Analysis as Required

Activities included completion and modification of human factors analyses as described in Section 2.1. During Phase II particular attention was given to those aspects of the analyses which are related to gunnery requirements.

2.2.3 Analysis and Interpretation of Phase I Data

During Phase II, the reduction, analysis, and interpretation of Phase I data was undertaken. The analysis included:

- Compilation and analysis of data obtained from the Phase I human factors questionnaire.
- Compilation and analysis of data relevant to the human factors evaluation which were collected using questionnaires developed by other evaluation elements.
- Enumeration of problem areas identified in the training evaluation with indications of the magnitude and severity of the problems.

- Integration of problems identified from the several sources enumerated above.
- Assessment of potential causal factors and development of candidate solutions to identified problems.
- Identification of areas where additional information or clarification are needed from Phase II and III evaluations to resolve inconsistencies, incompatibilities, and gaps in the data base obtained in Phase I.

2.3 Phase III - Battalion Field Training and ATT

2.3.1 Battalion Evaluation

During the conduct of the Battalion Field Training and ATT the primary human factors evaluation activities involved acquiring additional data on problems identified in Phases I and II, and collecting information on crew and crewman performance with individual tanks, platoons, and companies comprising an integrated fighting unit at the Battalion level. A good deal of emphasis was placed on communications problems during this phase, due to the nature of the activities.

The techniques used to collect information during Phase III evaluations were the same as those described for Phases I and II.

2.3.2 Continuation and Update of Human Factors Analyses

The human factors analyses were continued as described for Phase II (Section 2.2.2) with the exception that in Phase III particular attention was given to tank maneuvering and coordination with other elements.

2.3.3 Analysis and Integration of Human Factors Evaluation Data

In this step all data obtained during the evaluation were subjected to analysis and integration. The problem areas investigated and the methods implemented in their solution include:

- Personnel selection analysis techniques - correlation of questionnaire and interview data with performance measurements, and training problems identified for specific crewmen.

- Training - compilation of training problems identified in each phase. Correlation of training problems with performance problems. Review of trainee and instructor comments, opinions, insights, and attitudes. Development of recommended changes in the training program with indications of the impact of the changes on training effectiveness.

- Manuals and Publications - evaluation of document readability, organization, and use readiness.

- Doctrine of employment and tactics - treated only to the extent that they are affected by human performance capability and safety.

- Operating procedures - adequacy of techniques and sequences given the operational and environmental conditions existing during the test, and the hardware design configuration present in the tanks during the test.

- Equipment design - for operability, maintainability, and safety. Particular attention will be given to identification of problems and causal factors, and assessing the degree to which problems can be circumvented through changes in procedures, training, selection, or tactics.

- Communications - compilation of equipment design problems, standard procedures, message readability, etc., as they affect communications effectiveness. Determination of causal factors for problems and development of recommended solutions.

- Interrelation of the above areas to identify dependencies and interactions existing across them. Development of changes in each area and determination of the effect of these changes on other areas.

3.0 RESULTS AND DISCUSSION

This section will describe and discuss the results of the human factors evaluation of the M60A2 tank system. The results are presented in the following categories:

1. Personnel Selection
2. Training - Operations and Maintenance
3. Operational and Maintenance Procedures
4. Manuals and Publications
5. Equipment Design
6. Communications

The following subsections describe the findings and conclusions formulated during the M60A2 evaluation for each of the above listed categories.

3.1 Personnel Selection Evaluation

3.1.1 General

Personnel selection criteria usually include such factors as physical and mental requirements, and required skills, skill levels, and knowledge associated with a designated position. No attempt to directly measure test subject skills and skill levels was made since general agreement was not available regarding just what skills and skill levels were required for each tank crew position.

3.1.2 Results and Discussion

The only applicable information obtained during the M60A2 ICTT for assessing personnel selection criteria were derived from interviews and questionnaires. Company commanders and tank commanders were asked (during interviews at the conclusion of the Training Phase and the Gunnery Phase) to describe special physical, mental, and skill requirements associated with crew positions in the M60A2. Representative responses included the following:

- Physical
  - due to confined workspace crewmen should be small (See page 29)
  - crewmen should be tall enough to have visual access through hatches and periscopes (See page 29)
- Mental
  - crewmen must be intelligent and motivated
  - for the loader position, the average loader with an MOS of 11E10 does not understand what he is to do
  - loader needs to be at least an 11E20 due to increased skill requirements

- crewmen need to be safety conscious

- Skills

  - current aptitude areas seem to be adequate
  - no crewman needs a strong background in electronics
  - gunners should have a higher skill level than drivers
  - generally the skill levels authorized for each crewmember should be maintained with the possible exception of the loader position (some TC's recommend upgrading the position to an E4 and designating it assistant gunner).

3.1.3 Conclusions - Problems

The only problem areas identified for personnel selection were that larger soldiers had difficulties, and that current loader skill requirements may be insufficient. The magnitude of the problems has not been specified.

3.2 Training Evaluation

3.2.1 Introduction

The objective of the evaluation of M60A2 personnel training was to establish the general effectiveness of such training and to identify specific problems associated with training courses. The evaluation was conducted for tank crew training and for maintenance personnel training.

The information used in the evaluation of training was obtained through questionnaires, interviews, and direct observation of training classes and exercises by human factors evaluations. The structure of the training evaluation included the following specific evaluation dimensions:

- Evaluation of course content or the quantity and quality of training information presented, in terms of:

  - course comprehensiveness or breadth of material - does course content include all inforamtion which a trainee needs to know?

- course coverage or level of specificity of material - does course content include material at the depth required by trainees?

- course clarity - are instructions and information clear and unambiguous?

- course consistency - are training methods and procedures consistent and standardized?

- course compatibility - is the level of detail consistent with the progression of the trainee in the course?

- Evaluation of instructor skills and knowledges

  - do they have technical skills and knowledges?

  - do they have requisite instructional skills?

  - are skills and knowledges consistent across instructors?

- Evaluation of training aids and materials

  - are they well organized and meaningful?

  - are they in sufficient quantity for the number of trainees?

  - are they consistent across courses?

- Evaluation of training measures and criteria

  - are criteria (standards of performance) well defined, attainable, and quantified?

  - are measures of training defined and quantified?

  - are measures structured to enable identification of weak areas?

  - are measures applied consistently across crewmen, crews, platoons, and companies?

- Evaluation of training effectiveness

  - is remedial training directed to identified weak areas?

  - is remedial training consistent over all trainees, crews, platoons, and companies?

  - is the individual trainee confident of his acquired skills and knowledges?

- what is the degree to which personnel possess required skills and knowledge at termination of training?

- what is the degree to which each tank crew represents an integrated and well coordinated unit at the conclusion of training?

The following sections contain the results of the training evaluation and the identified problem areas for tank crew training and maintenance personnel training.

3.2.2 Crew Training Evaluation

3.2.2.1 General

The data collection methods used in this assessment of crew training included observation, interview, and use of questionnaires. The observation entailed having human factors evaluators observe and assess crew training activities in classroom situations and in the field. The evaluators observed training in all areas listed above with the exception of the cadre course. Interviews comprised discussions with instructors and trainees throughout the training program. Interviews were largely informal since non-interference with on-going activities was a constraint placed on all data collection activities throughout the human factors evaluation program. Interviews were structured to the extent that the information sought by the evaluators had been identified as the basis of analysis of data from observations, questionnaires, and training program plans and protocol. Several formal interviews were held during the training program, specifically with company commanders and tank commanders. These interviews were set up by MASSTER personnel who invited the human factors evaluators to participate.

Questionnaires were administered to tank crews at the conclusion of

Phases I and II. These interviews were developed by MASSTER evaluation elements and by human factors evaluators. The primary objective of the interviews was to sample the views, opinions, attitudes, and insights of tank crews concerning the training they received, their own learned levels of skill and knowledge, and the M60A2 tank system itself.

A fourth evaluation method used extensively by human factors evaluators consisted of gathering data from the other evaluators participating in the ICTT. Human factors personnel attended daily meetings of all evaluators where the status and problem areas identified in the ICTT were discussed. They also accompanied company evaluators in all field exercises, riding in a jeep either with or directly behind the company evaluators.

3.2.2.2 Results and Discussion

The segments of M60A2 crew training which were subjected to a formal evaluation included:

1. The cadre course for TC's and gunners at the Armor School, Ft. Knox.
2. Individual training for drivers and loaders at Ft. Hood, conducted by the TC's and gunners who had participated in the cadre course.
3. Gunnery training, specifically during ICTT Phase II.
4. Overall training conducted during the three ICTT phases which consisted of field instruction, familiarization, on-the-job training, and practice for unit ATT's (platoon company, and battalion). The evaluation of overall training will not be treated as a separate subject but will be included in segments 1, 2 and 3 above.

The results of the training evaluation for the first three segments are described below.

1. Evaluation of Cadre Training at Fort Knox

Tank commanders and gunners attended a cadre training course at Ft, Knox where they received 51 hours in instruction and another 51 hours in gunnery exercises on the M60A2 tank systems. The major course subjects included:

- armament, controls, and equipment — 11 hours
- mechanical training - machine gun — 4 hours
- missiles and conventional ammunition — 2 hours
- conduct of fire — 8 hours
- auxiliary fire control instrumentation and range cards — 4 hours
- prepare to fire procedures — 8 hours
- target acquisition — 8 hours
- M42/43 conduct of fire trainer — 4 hours
- operator maintenance — 2 hours

The gunnery exercises included:

- preliminary gunnery examination — 8 hours
- sub caliber firing — 4 hours
- stationary and moving targets- day — 8 hours
  - night — 4 hours
- stabilized gunnery exercise — 7 hours
- machine gun exercise - day — 8 hours
  - night — 4 hours
- crew field firing — 8 hours

The general opinion of tank crewmen (as indicated in following paragraphs) who participated in the cadre training at Ft. Knox was that it was satisfactory. It is difficult to determine if this was due to the experience levels of the crewmen, the level of hands-on training which they received, or the quality of the training itself.

Course Content-Comprehensiveness

One problem with the scope of the cadre course was identified by company B TC's who stated in the tank commander interviews that the TC does need instruction on turret maintenance which he currently does not get in the cadre course.

Another problem area associated primarily with the scope of the training related to the use of passive night sights. This sight is included in both the gunner's periscope (M-50) and the Tank Commanders' periscope (M-51) when used on the 10 power setting. All Company C platoon leaders stated that their crews did not receive sufficient training at Ft. Knox because of maintenance problems with the available M60A2 tanks. These vehicles began to experience failures (not in the passive night devices) and were unavailable for training. This situation carried over to the other company B, which attended the Ft. Knox school.

Training on the passive sight system was limited to classroom instruction on how to turn the system ON and OFF. The "C" Company platoon leaders interviewed stated that the platoon learned how to use the passive night sights by reading the Operator's Manual, TM-9-2350-232-10 and following the instructions. The problem with the passive night sight training is twofold:

1. Lack of training in the formal school setting

2. Pattern or form recognition

The two are interrelated, but it should be noted that successful operations can be conducted if personnel utilize training periods effectively (i.e., hands-on training during periods in the field). According to the platoon leaders interviewed, the best method to learn use of the sights is to use them against a known target by scanning the "aggressor" area at the horizon to obtain optimum contrast. That is, obtain a target against a light or dark background or to look for a discontinuity against the horizon. It is apparent that the operator must know the general form of his target in order to minimize detection or search time. Also, the best method for training would be to place a target at a known location and allowing all tank personnel to scan the target area, acquire and identify the target. This allows everyone to become familiar with the system.

Course Content - Completeness or Depth of Coverage

When asked if they had received sufficient training at the Armor School to prepare for their duties as tank commander and gunner, only 17% of the 75 TC's and gunners questioned responded with an unequivocal yes. An additional 76% (57 individuals) answered yes with the stipulation that additional on-the-job training was required. Only 6 percent responded that they had not received sufficient training at Ft. Knox.

Each TC and gunner was asked if they felt that they needed more or less time on each major subject and gunnery exercise than the time allocated in the course. The results, as percentages of responses for the subjects and exercises, are depicted in figures 1 and 2 respectively.

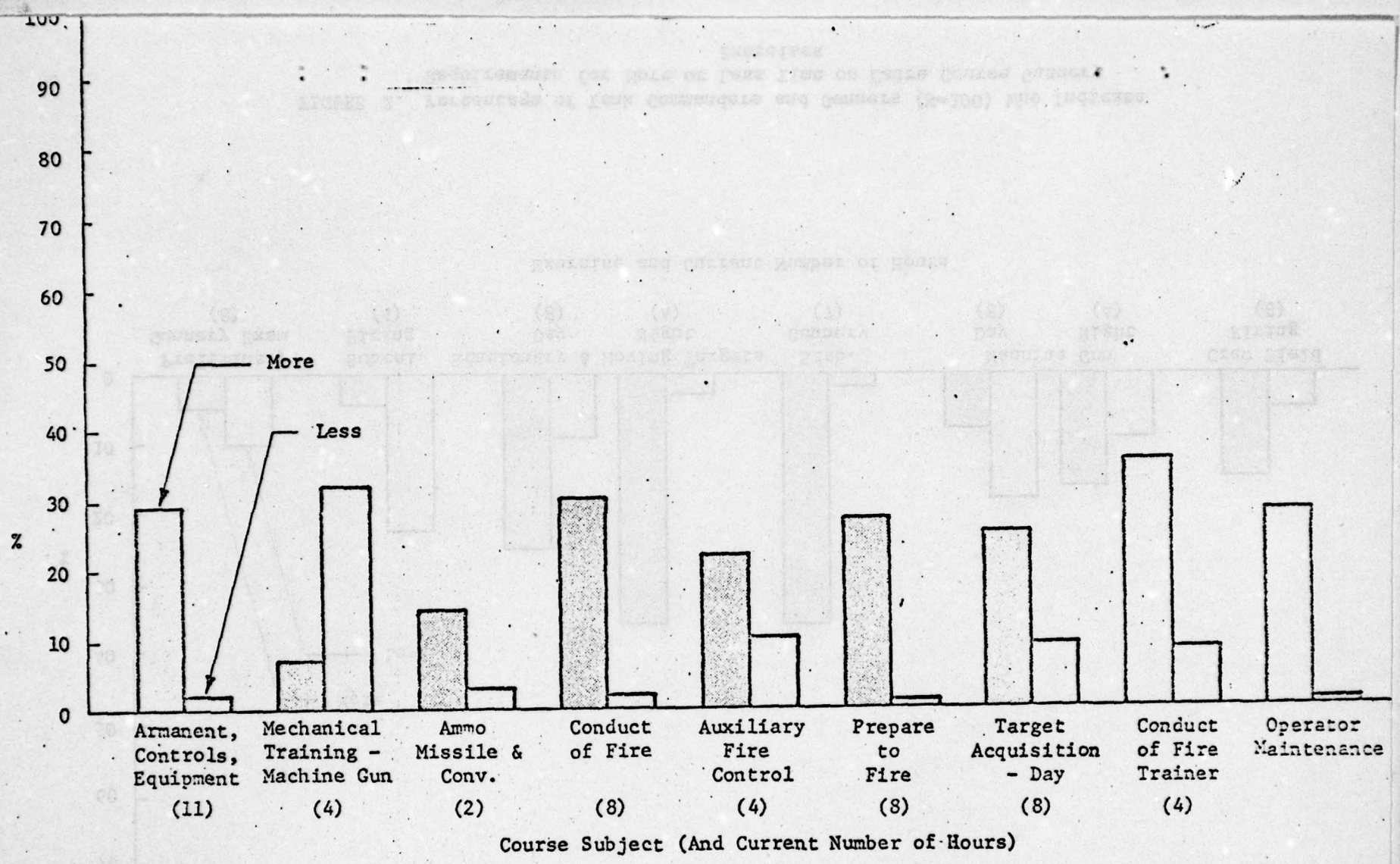

FIGURE 1. Percentages of Tank Commanders and Gunners (N=100) Who Indicate Requirements for more or less time on Cadre Course Subjects

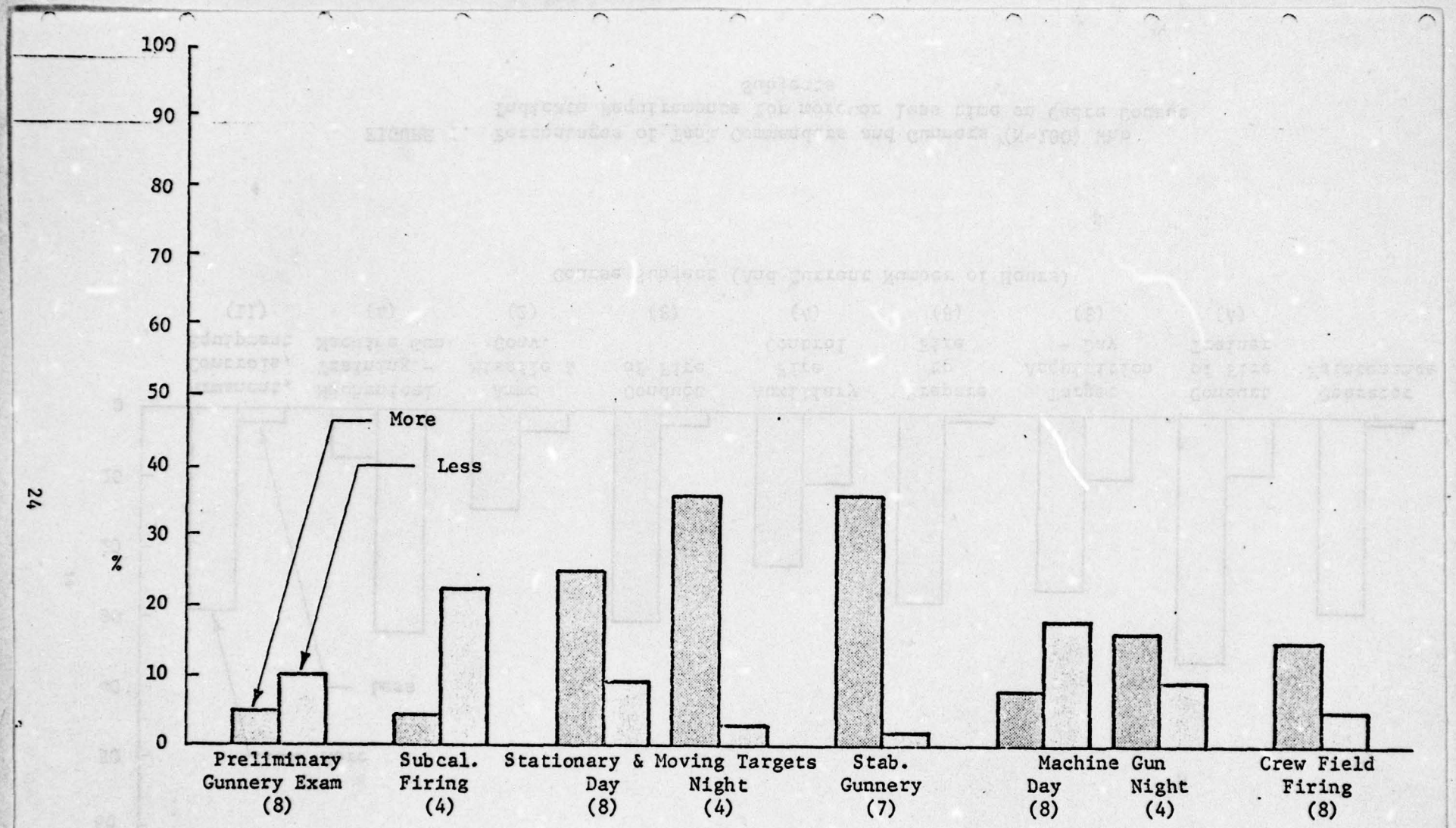

FIGURE 2. Percentage of Tank Commanders and Gunners (N=100) Who Indicate Requirements for More or Less Time on Cadre Course Gunnery Exercises

As indicated in figure 1, approximately 30% of the 100 TC's and gunners felt that they needed more time on 8 of the 9 subjects taught in the cadre course. The subjects receiving the highest frequency of responses for more training were:

a) conduct of fire trainer
b) conduct of fire
c) operator maintenance
d) prepare to fire,
e) armament, controls and equipment

From figure 2 it is evident that of those who felt that a change was necessary, TC's and gunners felt that more training was required on 5 of the 8 exercises. The exercises receiving the greatest proportion of such opinions were: stationary and moving targets -- night, and stabilized gunnery.

From these results it is concluded that the primary areas where TC's and gunners feel that additional training coverage is needed in the cadre course are those which apply directly to gunnery (specifically conduct of fire, prepare to fire procedures, armament, stationary and moving targets, and stabilized gunnery) and to operator maintenance.

Course Content - Clarity

No problems identified

Course Content - Consistency

No problems identified for the level of progression of course mentioned and for standardization of training procedures.

Course Content - Compatibility

No problems identified

Instructor Skills and Knowledge

No problems identified

Training Aids and Materials

Tank Commanders and gunners were asked at the end of the training phase to indicate their opinions of the cadre course training aids and materials. The summary of three opinions is as follows:

- 93% (70) stated that training aids were helpful and easily understood
- 46% (33) said that the amount of hands-on equipment time was adequate
- 59% (44) felt that the number of training aids was sufficient so that all students could benefit from them

There is, therefore, no problem with the training aids themselves, in terms of crew opinions. There is a problem with the adequacy of hands-on equipment time at the Cadre School. This problem is probably due to the distribution of classroom instruction and practical application. When asked how the cadre course should be structured in terms of amount of classroom instruction or practical application, the TC's and gunners were strongly in favor of a greater allocation of time for practical application, which would include hands-on equipment time (69% wanted two thirds or more of the time spent on major subjects in the course given over to practical applications, while for gunnery exercises the proportion who wanted two thirds or more of the time given over to practice was 80%). This problem should not be resolved at the expense of classroom instruction time, since only a very few of the TC's and gunners requested less time spent on any course area (figures 1 and 2). Additional time should be allocated for practical application of information learned in classroom instruction, and added to the time currently scheduled for the course.

The finding that 59% of the TC's and gunners who had attended the cadre course were satisfied with the number of training aids, at the end of Phase I, is contradictory to a finding (from Phase II questionnaires) that only 25% of 79 TC's and gunners rated the number of students per training aid as adequate. When asked to identify an adequate ratio, the respondents (63) were highly variable in their opinions, as indicated below:

Number of Students per Aid	Number Selecting	% of Total
one	2	3
two	31	50
three	5	8
four	14	22
five to seven	11	19

One half of the TC's and gunners favor 2 students per aid, and 41% favor between four and seven. No explanation for this bimodal distribution is currently available.

Training Measures and Criteria

No detailed research information was obtained on the testing which terminated the cadre course. This testing is primarily directed at determining if the student possesses the skills and knowledges required at the conclusion of the course, and his performance is scaled in terms of pass or fail. Consideration should be given to identifying weak areas of skills and knowledges for each student, even if he passes and especially if he fails. Feedback of weaknesses to the student should serve to direct and focus his efforts toward improving his skills.

Overall effectiveness of the cadre course

A group of 9 evaluators and platoon leaders who had participated in the cadre training rated it good (55%) and very good (45%). Tank commanders and gunners rated the course as very good (51%), good (46%) and borderline (3%).

A total of 24% (24 of 99) of the TC's and gunners who were trained on the A2 did not take the cadre course. Of these, 2% received A2 training at Knox, 12% had A2 training elsewhere, and 10% had no A2 training at all.

A total of 93% (68 of 73) of the TC's/gunners reported the classroom instruction in the cadre course to be adequate, and 93% also indicated that the amount of time spent in individual study and review was adequate. One potential problem area was in the amount of hands-on equipment time, where only 46% reported that it was adequate. This was probably due to the shortage of tanks and training aids during the course (see training aid evaluation)

An evaluation of the effectiveness of the training given at the Armor School was made by evaluators and platoon leaders when they were asked to rate the need for the cadre training. The question, presented to 11 individuals who stated that they had the opportunity to compare performance of Ft. Knox trained personnel with those getting OJT only, was, what was the relative effectiveness of each type of training?

- A total of 55% of evaluators and platoon leaders stated that the need for cadre training was demonstrated in that Ft. Knox trained personnel consistently outperformed those who acquired the same skills through OJT.
- The remaining 45% judged the need for cadre training to be marginal since people who attended the course initially outperformed those receiving OJT, but after a few weeks the performance of each group was about equal.

- No evaluators and platoon leaders reported that OJT people consistently outperformed cadre trained people

Two items in this finding remain unclear. First, how did the evaluators and platoon leaders define OJT trained people. While 76% (75 of 99) of the TC's and gunners trained at Ft. Knox took the cadre course, 14% stated that they had received M60A2 training elsewhere (at Ft. Knox but not in the cadre course, and at other locations), and 10% stated that they had never been trained in the M60A2. Was the OJT group composed of all those who had not taken the cadre course (but some of which had received formal training), or only of those who had not received any formal training in the tank.

The second point which is unclear in the reported comparison of cadre trained and OJT trained personnel is, how was the evaluation conducted? Was it based on subjective impressions? made on an established schedule or at random? or was it based on objective performance measures obtained on personnel of the two groups during platoon and company ATT's?

It is interesting to note that all evaluators and platoon leaders rate the cadre course training as either good or very good (no person gave a rating lower than these two). However, almost half of this group stated that the need for cadre training, as compared with OJT, is marginal. One additional factor not accounted for in this finding is, to what degree is OJT effective insofar as it is conducted by instructors trained in the cadre course.

When all tank crewmen were asked at the end of Phase II to rank the importance of several factors in making a successful transition from the M60A1 to the A2, the highest rated item was OJT (39% or 58 of 198 responses ranked it first). The second ranked factors were special training, specifically cadre, and physical size, both of which were ranked as most

important by 27% of the crewmen.

2. Evaluation of Individual Training of Loaders and Drivers

The individual training of loaders and drivers was conducted at Ft. Hood, by TC's and gunners who had attended the cadre course. A total of 80% of the loaders and drivers trained in the M60A2 ICTT (62 of 78) reported that they had participated in the individual training. The duration of the training varied by company due to test scheduling difficulties. C company received the largest training period, almost 3 weeks.

The evaluation of the individual training is presented below:

Course Content - Comprehensiveness - no problems identified

Course Content - Coverage

Loaders, drivers, TC's and gunners, were asked to determine if the individual training given to loaders and gunners was sufficient. The questions were asked along four dimensions:

- time in classroom instruction
- time for practical exercises
- hands-on time
- coverage of all subjects

Figure 3 depicts the responses of the two groups in terms of the percentages who reported that coverage along these dimensions was inadequate or insufficient. Generally the two groups (loaders/drivers and TC's/gunners) were in close agreement on classroom time and subject coverage. The loaders/drivers were more critical of the time for practical exercises and hands on time than were TC's/gunners. The overall result is that 4 of 10 tank crewmen are of the opinion that the time for exercises, the hands on time, and the subject coverage in the in-

dividual training was inadequate.

A breakdown of just where the inadequacies were, in terms of course coverage inadequacies, for loaders and drivers, is presented in figures 4 and 5 respectively.

As seen in figure 4 loaders were consistently more critical of the coverage of subjects in the individual training for loaders than were TC's and gunners. The only area where TC's and gunners exceeded loaders in terms of the number who viewed the training coverage as inadequate was crew drill.

The main weaknesses (at least one-third reporting inadequate coverage) of the individual training, according to loaders, were in:

- basic tank gunnery
- reduction of weapon malfunctions
- prepare ammunition for firing
- identification, stowage, and maintenance of ammunition
- crew maintenance
- loading tank weapons

Figure 5 presents the reported areas of inadequate coverage for drivers, reported by drivers and by TC's and gunners. As indicated in this figures, the drivers exceeded the TC's and gunners in terms of number who report inadequate coverage, on 8 of the 11 subject areas.

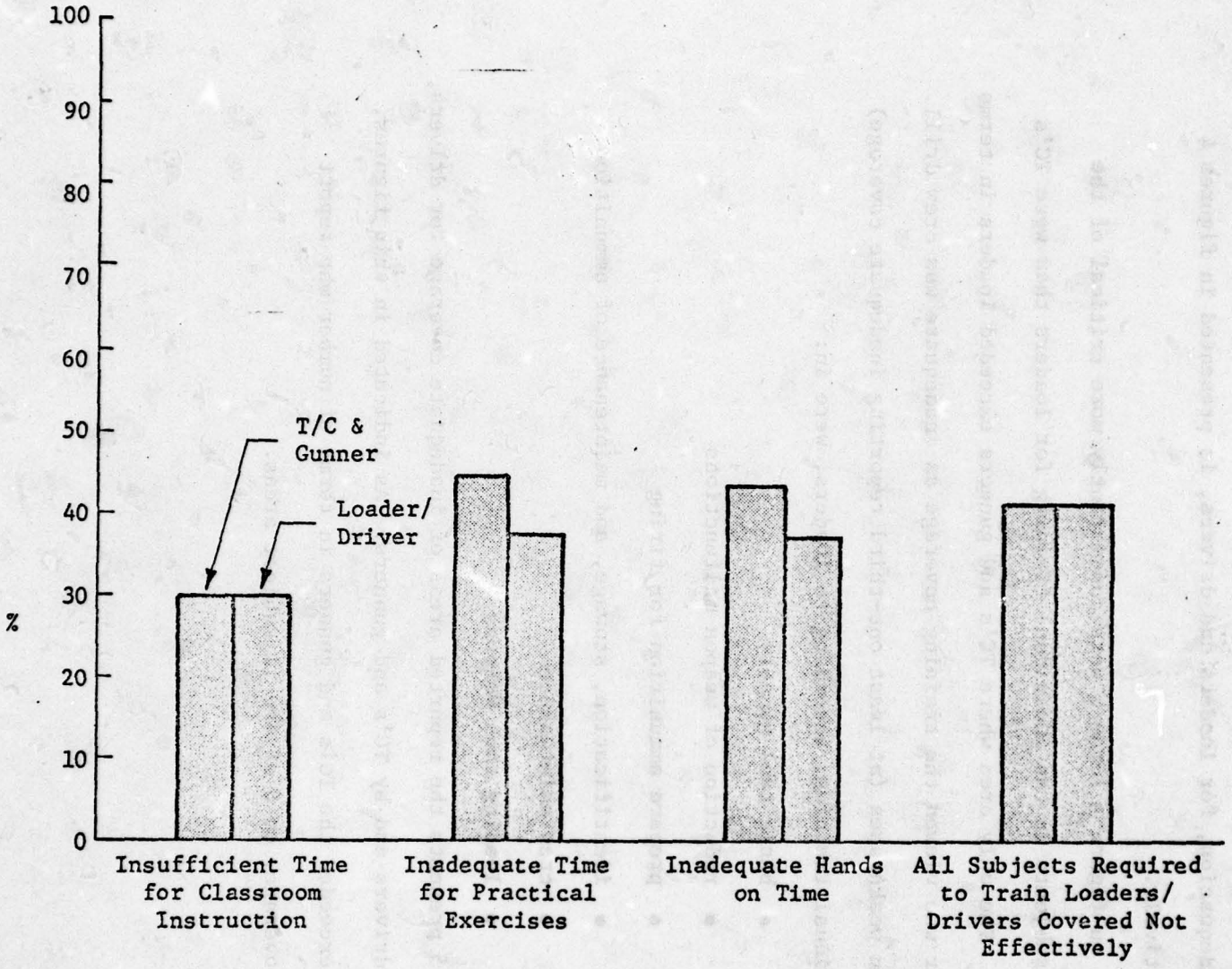

FIGURE 3. Evaluation of Loader and Driver Individual Training - As Estimated by TC & Gunners and by Loaders and Drivers (In Terms of Percentage Who Respond Unfavorably) 75 Loaders and Drivers, 35 TC's and Gunners

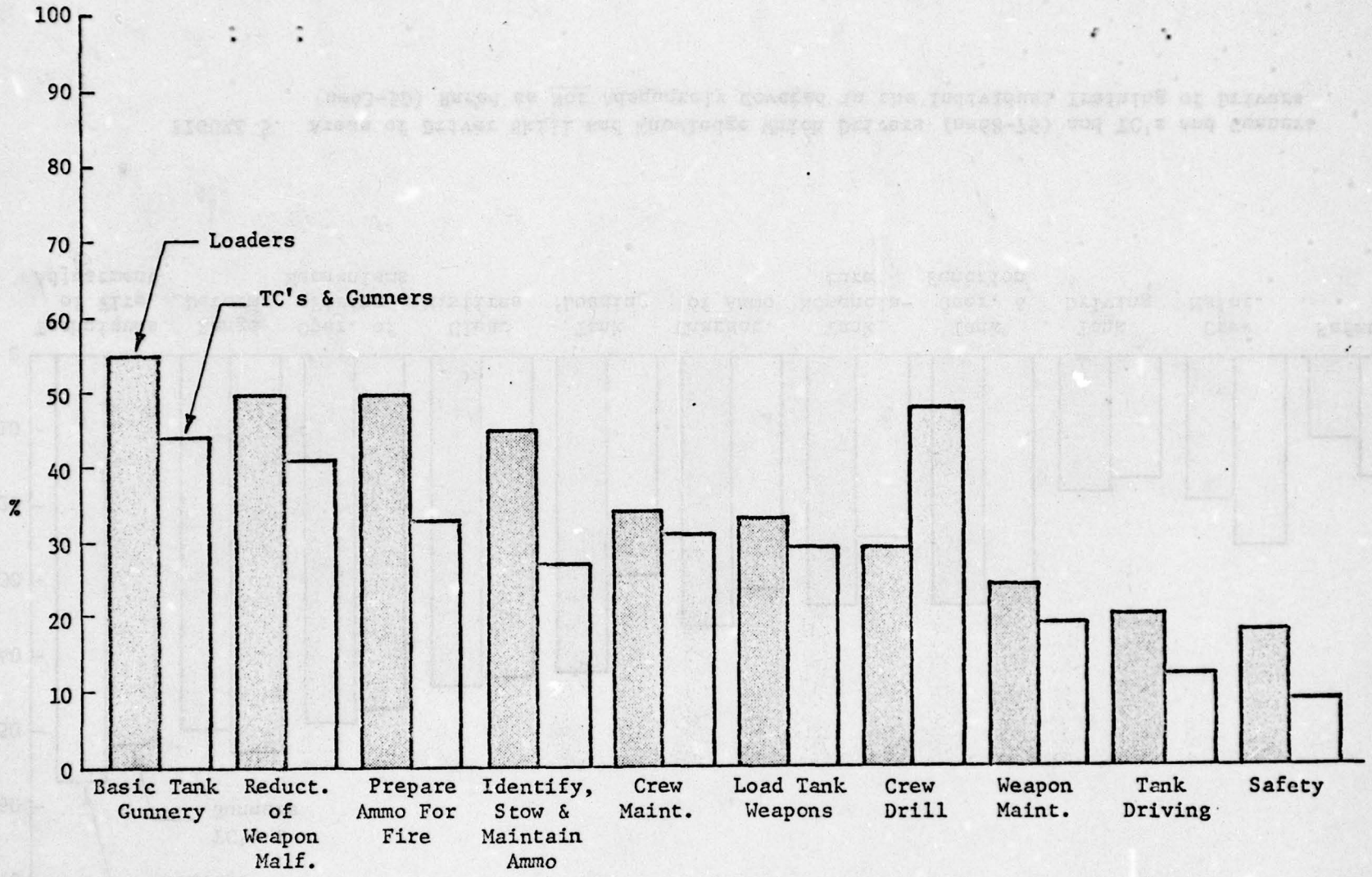

FIGURE 4. Areas of Loader Skill and Knowledge Which Loaders (n=47-53) and TC's and Gunners (n=50) Felt Were Not Adequately Covered in the Individual Training of Loaders

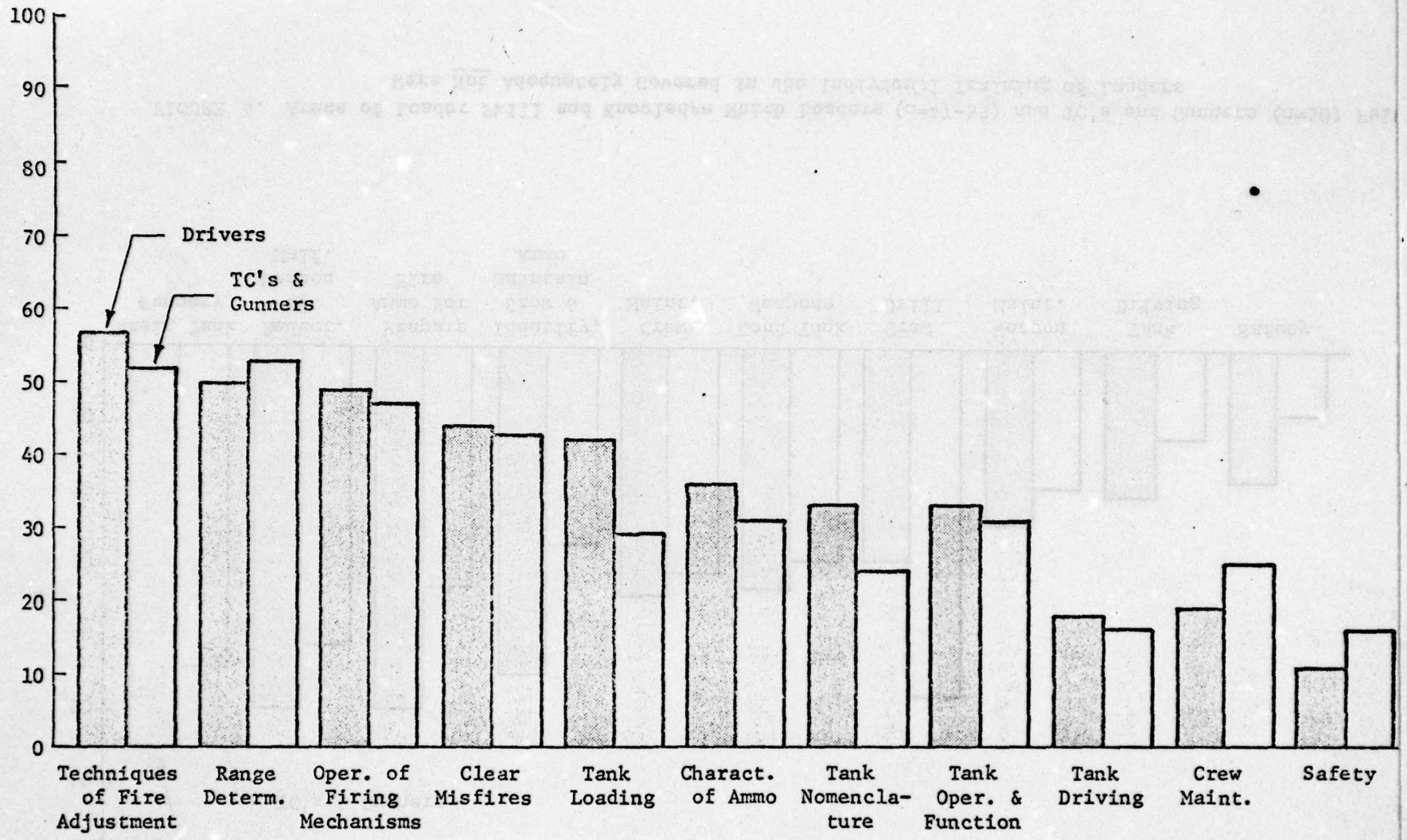

FIGURE 5. Areas of Driver Skill and Knowledge Which Drivers (n=68-76) and TC's and Gunners (n=43-50) Rated as Not Adequately Covered in the Individual Training of Drivers

The major problem areas for subject coverage as reported by drivers (at least one third reporting inadequacies) were:

- techniques of fire adjustment
- range determination
- operation of firing mechanisms
- clearing of misfires
- tank loading
- characteristics of ammunition
- tank nomenclature
- tank operation and functioning

One possible explanation for the large proportion of training areas judged inadequately covered by a relatively large percentage of drivers and loaders has to do with the orientation of instructors for the individual training. The instructors follow lesson plans developed by the company but it must be recognized that, since these plans are generated by line troops, they are apt to reflect those things that are considered essential by the person preparing them. Personal preferences are highlighted which do not always encompass the situation. Also, there is a tendency for the person(s) preparing the lesson plan and for the instructors to assume that the personnel being trained were knowledgeable on all aspects of the system with the result that certain items do not receive sufficient coverage until they discover these during "hands-on" training.

Course Content - Clarity

No problems identified

Course Conent - Consistency

Lesson plans for individual training are generated at the company

level. It is not apparent that any coordination among companies existed to ensure that subjects presented to loaders and drivers in different companies were comparable at least in terms of content.

Course Content - Compatibility

One problem noted in informal interviews of loaders and drivers was their feeling that subjects were being presented to them in a fixed order and at a predetermined degree of detail without any consideration for their requirements or deficiencies. They felt that in some cases too much time was spent on things which they understood leaving less time for the areas where they needed more instruction.

Instructor skills and knowledges

No problem areas were identified in terms of the level of operational and technical skills and knowledges on the part of instructors. The primary problem was seen in their instruction skills. They had received little or no guidance on how to instruct the students in the individual training segment. Some were prepared while others were not. Some used training aids while others did not.

Training aids, materials and media

Training aids used in individual training were limited to items constructed of wood, plexiglass, or cardboard. The aids which were used were judged too few for the given class. Visual aids (vuegraphs) were not consistently used and usually reflected hasty preparation.

Training Measures and Criteria

It seems that no measures were taken of the degree to which loaders and gunners had comprehended the training presented to them in the individual training.

Training Effectiveness

At the conclusion of Phase I (training), which included individual training and platoon and company ATT's, each loader and driver was asked to rate the quality of the overall training. A total of 34% rated Phase I training as either bad or very bad, and 76% rated it as borderline or worse.

Loaders and drivers were also asked to assess the degree to which they were trained to perform their assigned duties at the end of Phase I. A total of 44% felt that they were sufficiently trained and that no additional training was necessary. Another 29% felt that additional on-the-job training was still required, and 26% stated that they were not trained to perform their duties and that additional individual training should have been provided.

Drivers and loaders were therefore not overly impressed with the training given them in the training phase of the ICTT. One in three rated the training as bad or very bad, and one in four stated that they were not sufficiently trained. About 4 out of 10 stated that sufficient time was not given to practical exercises, hands on equipment time, and coverage of subjects.

3. Evaluation of Gunnery Training

After completion of the company ATT the M60A2 tank crews began the Gunnery Phase of the ICTT. This phase consisted primarily of pregunnery training, the preliminary gunnery exam, and range firing on tank tables I through VIII. Most of the phase was given over to training in gunnery specific operations with two test periods injected to measure crew proficiency. These tests comprised the preliminary gunnery exam and tank table VIII.

Course Content - Comprehensiveness

No problems were identified. The scope of training was adequate. A total of 63% of all (144) tank crewmen attended at least 80% of the gunnery training and 88% attended at least half.

Course Content - Completeness, depth of coverage

Figure 6 presents responses of each of the four groups of crewmen concerning the adequacy of the coverage of gunnery training. As indicated in this figure a sizeable proportion of each crew position felt that gunnery training was borderline or worse. That the training did not prepare the crews for the tank tables was expressed by more TC's than any other duty station. Loaders were more satisfied with training than any other group, while drivers expressed the most dissatisfaction. TC's and gunners were fairly comparable in their response frequencies.

The specific areas where additional training coverage and time are required are indicated for the four positions in figure 7 and 8 respectively. Figure 7 presents the proportions of crewmen who report that training content and coverage must be improved in certain selected areas. Nearly all areas are cited as requiring changes by about one half of each duty position group. The item receiving the greatest proportion of reported needs for change is overall quantity of training.

When asked to identify areas in gunnery training where additional time is required (Figure 8) a good proportion of each of the four position groups responded that additional time is required for all areas. Time was spent in actual range firing and time spent on tables VI and VII received the highest proportions over all four groups.

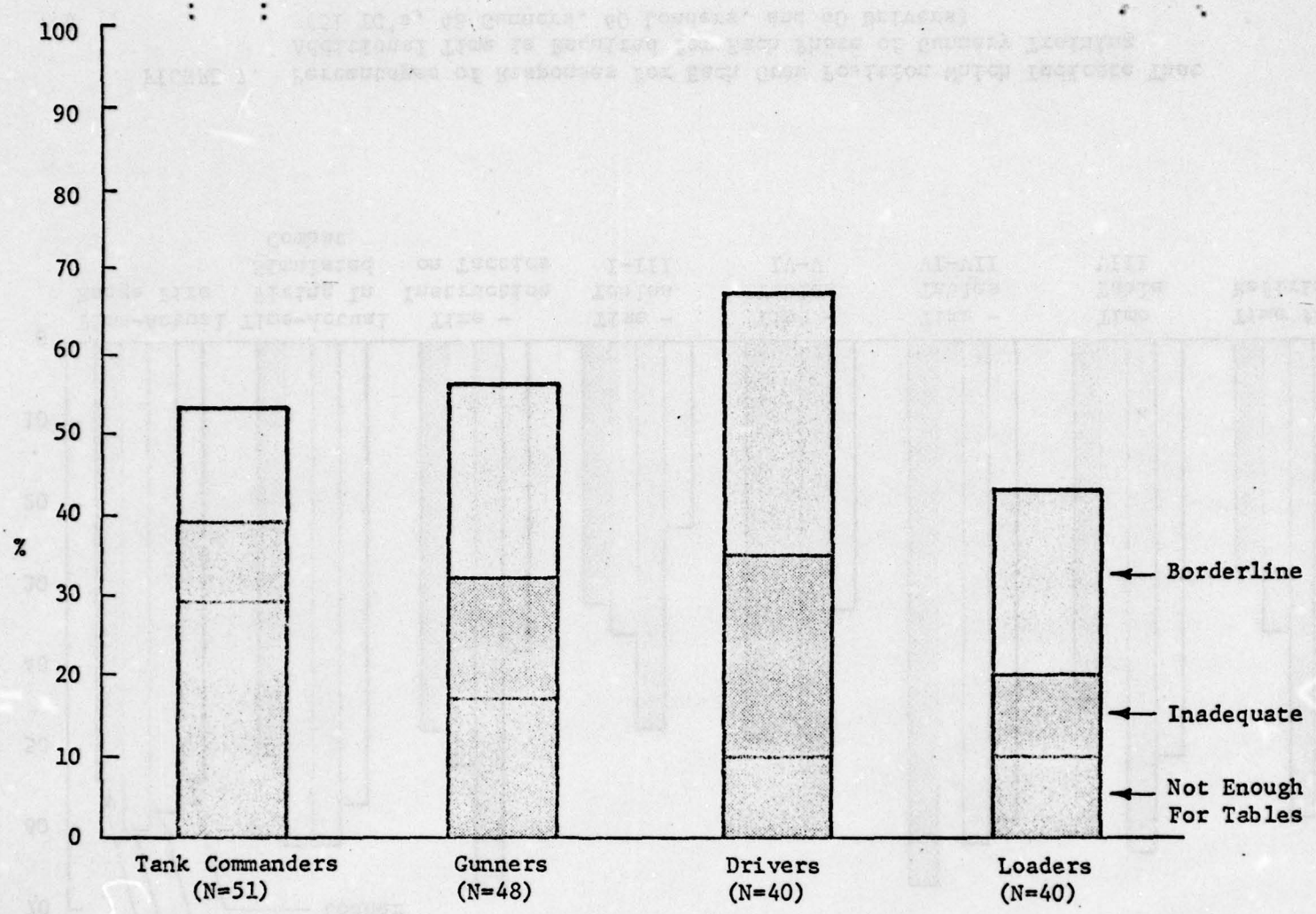

FIGURE 6. Evaluation of Adequacy of Subject Matter Coverage in Training by Representatives of Each Duty Station

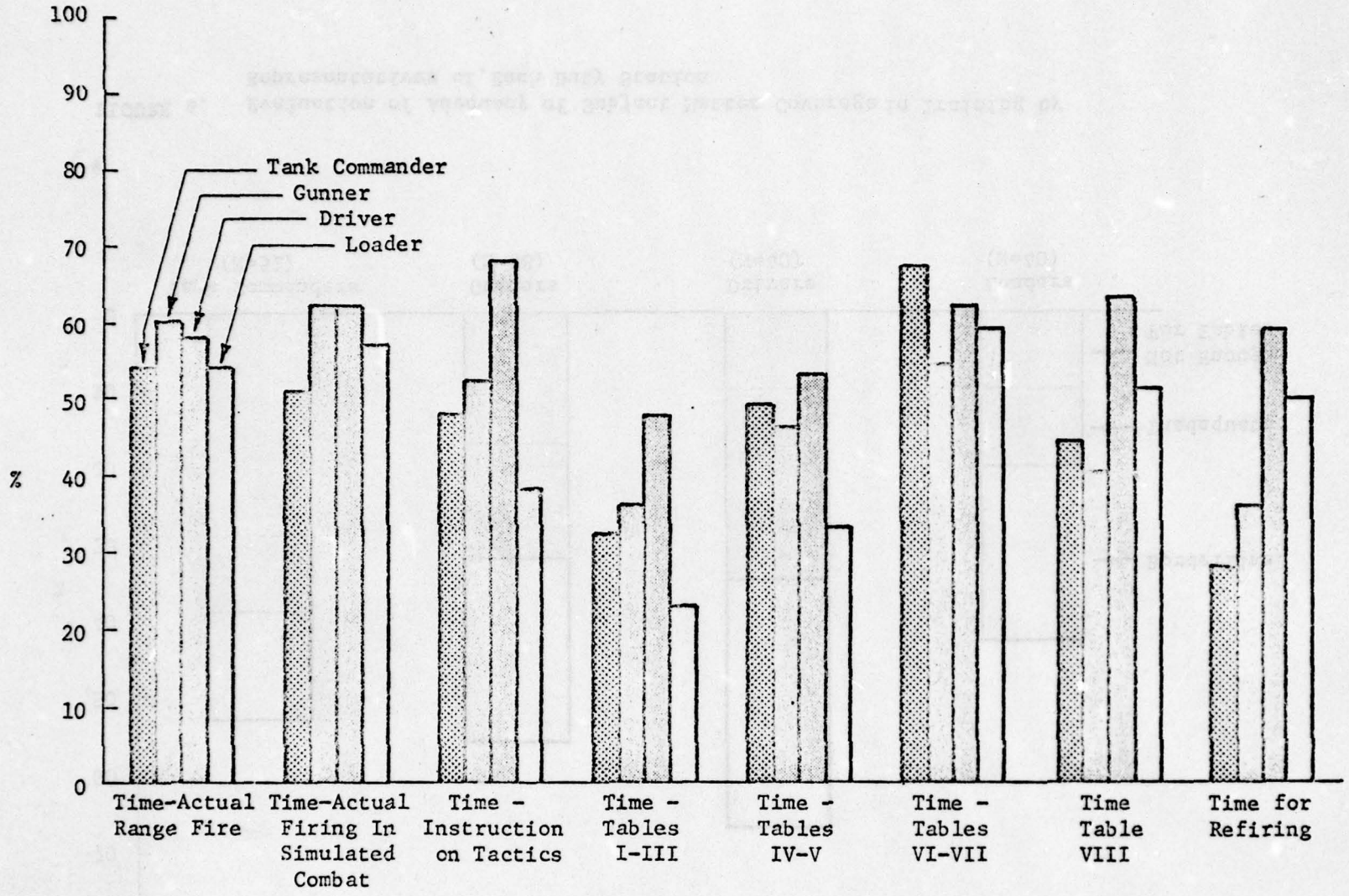

FIGURE 7. Percentages of Responses for Each Crew Position Which Indicate That Additional Time is Required for Each Phase of Gunnery Training (51 TC's, 48 Gunners, 40 Loaders, and 40 Drivers)

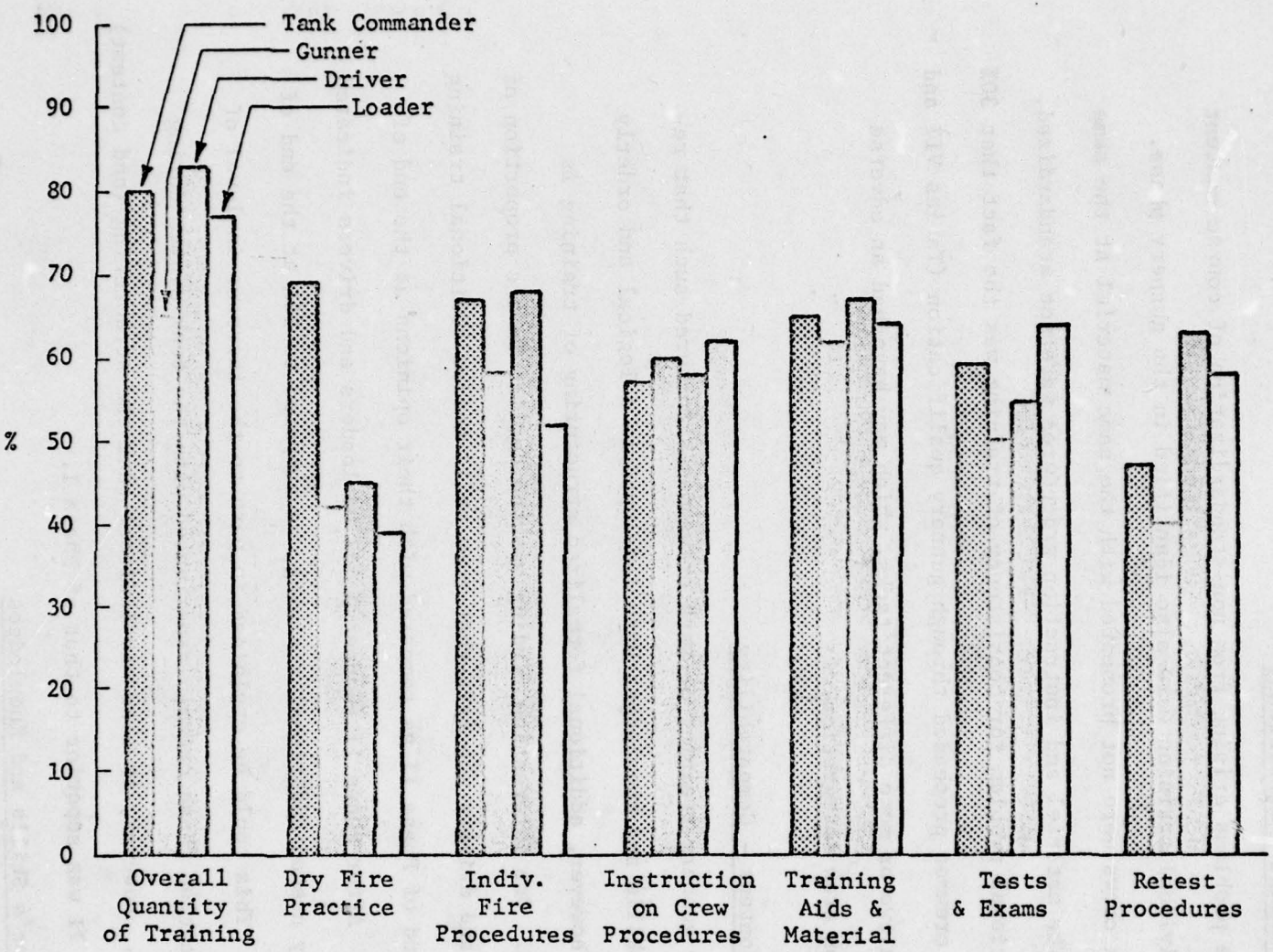

FIGURE 8. Percentage of Responses for Each Crew Position Which Indicate That Changes are Required in Gunnery Training Content and Coverage (51 TC's, 48 Gunners, 40 Loaders, and 40 Drivers)

Course Content - Clarity

No problems identified

Course Content - Consistency

The problems arising from non-standardization of course content for individual training were also identified in the gunnery phase. All tank crews were not presented with the same materiel at the same rate. The materiel and instruction procedures were not standardized. An additional problem for consistency of training was the fact that 30% of tank crewmen proceeded through gunnery qualification (Tables VII and VIII) in two or more different tanks, which may have had an adverse effect on crew integration.

Course Content - Compatability

The gunnery training of tank crews was structured such that required skills and knowledges were developed in a logical and orderly manner, however, additional formalized structuring of training is required. One interesting finding was the decline in the proportion of loaders and drivers who felt that they still needed additional training at the end of Phase II as compared with their opinions at the end of Phase I. After Phase II (Gunnery) 13% of loaders and drivers indicated that they needed additional training, as compared to 26% at the end of Phase I. This could be explained in part to the increase in level of sophistication these crewmen experienced with the tank system during Phase II. However, it also may indicate that the structuring (and content) of Phase II was superior to that of Phase I.

Instructor's Skills and Knowledges

While no crewmen explicitly identified it as a problem in interviews or via questionnaires, it was concluded based on direct observation

of training that the teaching skills of instructors during gunnery require improvement. The training conducted during the gunnery phase consists largely of on-the-job training, practice in conduct of fire drills, and practice in actual firing. There is little in the way of formal training, either in classroom instruction or in-the-field briefings. Whatever instructions there were came from platoon leaders and tank commanders who had attended the cadre course at Ft. Knox.

Consideration needs to be given to developing more structure into the gunnery training, including expanded use of skilled instructors. This is more critical in the early stages of the training since, if crewmen were to develop an incorrect understanding of their requirements, responsibilities, and procedures, they will spend much of the training phase in practicing these inappropriate procedures.

Training aids, materials, and media

In line with the problems associated with instructors' skill and knowledges, the more general problem of a lack of structure in the training program is also reflected in the absence of lesson plans and standardized training procedures and methods. The need for standardized and formal training aids and materials is most pronounced in pregunnery training, prior to the preliminary gunnery exam. The exam itself identifies the skills and knowledges which each crew member must possess in order to pass the exam. The period between initiation of the gunnery phase and the preliminary gunnery exam should be dedicated to administering classroom instruction followed up with on-the-job training and concentrated practice in those areas addressed in the exam, in a more formal manner. Lesson plans need to be developed and used universally to ensure standardization of material presentation and rate of presentation. Visual aids, including slides, vuegraphs,

and even motion pictures should be developed as part of a standardized training package. In each classroom instruction period or day, trainees must be provided with handouts reviewing the material presented in the period, for review and reference during follow up practice and during periods allocated for study and review.

Training Measures and Criteria

The principal measures of training implemented during the Gunnery Phase consisted of the preliminary gunnery exam (PGE) and Tank Table VIII on the range. The PGE was primarily concerned with testing crew knowledge of gunnery procedures and practices. The crews reported to eight test stations sequentially and were tested on different aspects of gunnery operations at each station. They were tested and scored by TC's and platoon leaders from within the Battalion but from a different company. Generally the testing consisted of scoring a crew member as either passing or failing the individual test conducted at a station. Specifics concerning performance on each test item, such as what the response was when it was an incorrect response, or what the crewman did wrong in following a procedural sequence, were not recorded. If a crewmember failed the test at a station, he reported to an additional station after leaving the eighth and last test station, where he was briefed on the material involved in the operation which he missed. He then went to a retest station where he was tested on the same material.

Philosophically there is nothing basically wrong with this retest procedure since the purpose of a test of training should be to impart additional training as well as to examine the trainee on what he knows and his level of skill. However, there are two basic problems with the general approach.

Under the current procedure, a crewman could be wrong, or at least unsure of certain procedures at a station, and still pass the test at the station. A better approach would be to provide remedial training on all items missed or where performance is doubtful or incorrect. This remedial training should be administered immediately, at the same station, prior to moving to the next station. In this procedure, there would be no grading of performance in this initial testing sequence. It would be conducted for purposes of identifying where additional training is required and for providing that remedial training immediately. After sequencing each crewmen through all stations, they would then return to each station for the formal test.

The second problem area is the short time period between remedial training and final test in the current approach. In order to ensure that crewmen have indeed learned the procedures which were scored as weak or failed during the test, at least one day should elapse between remedial training and final testing. If personnel fail the retest they should then retake the entire course, or they should be washed out.

Training Effectiveness

An indication of the effectiveness of gunnery training can be obtained from opinions of crewmen who went through the training for gunnery.

As indicated in Figure 6, about half of the TC's and loaders stated that gunnery training was adequate or very good. About 4 of 10 gunners so rated gunnery training, while only one-third of the drivers were satisfied with the gunnery training. The TC's were most critical of gunnery training, with 29% of them stating that it was not sufficient for beginning range firing on the tank tables.

When asked specifically if gunnery training was adequate, in interviews after termination of Phase II, all tank commanders from all three companies answered definitely and emphatically in the negative. The significant weaknesses of the training cited by TC's included:

- main gun firing - All A Company TC's
- unavailability of the conduct of fire trainer - B and C companies
- insufficient time to gain understanding of procedures - B company
- training on specific operations inadequate - C company
  - laser range finder operations
  - boresighting
  - fire control procedures
  - burst on target operations
- in addition, all Company TC's objected to the structure and format of fire commands as presented in the operations manual

Company commanders were also asked in an interview, for their opinion of the adequacy of tank gunnery training late in Phase II. Their opinions were unanimous that the training was inadequate. Their views closely parallel those expressed by their TC's. Representative comments were:

- There is a need for more time for gunnery training - up to six months
- There is a need for improved familiarization of all aspects of gunnery, especially crew drill and stabilized gunnery
- Gunnery should receive the highest priority in the allocation of training time. This should extend throughout the entire training phase and not merely begin after the ATT's.
- Company Commanders didn't have sufficient flexibility in scheduling and administering training exercises to their crews

The TC's and company commanders were also asked in the interviews if crew members had sufficient knowledge of the tank systems to enable them to

perform their duties. The responses indicated that while drivers and loaders seem to have adequate knowledge of their own positions, they need more training on other positions. Tank Commanders were a good deal more critical of the skills and knowledges of TC's and gunners than were company commanders. The CO's stated that TC's and gunners need more gunnery experience, more training in conduct of fire, procedures in general, and identifying malfunctions. One CO stated that not all of his TC's and gunners went to the cadre school, and that they generally need more classroom instruction.

Tank commanders, in evaluating the levels of skills and knowledges of TC's and gunners after gunnery training, were more emphatic in their assertion that they were not adequately trained, and were more explicit in citing weak areas. The TC's of each company stated almost unanimously that TC's and gunners do not have adequate knowledge of the M60A2 tank. The two main problems which they identified for training were insufficient gunnery training and a need for more and better crew maintenance training. Company B TC's stated that TC's need to go to school for training on turret maintenance. C Company TC's indicated that a need exists to reallocate maintenance tasks to give the tank crew more responsibility in making the tank function.

Tank commanders reported that weak areas in the knowledge and skill possessed by TC's and gunners included:

- stabilized gunnery techniques
- fire control instruments
- transition from active light to passive light engagement
- troubleshooting
- boresighting
- fire commands

- night firing
- crew drill
- turret operations

TC's also reported that some part of the training problem was due to the inadequacy of available checklists and manuals. They felt that checklists are too long and complicated. They also reported that, in most cases, the manuals simply are not used.

Loaders and drivers had been asked on a questionnaire to give their opinions of overall tank training at the end of the Training Phase and at the end of the Gunnery Phase. Their responses were as follows:

	n=81 After Training Phase (I)	n=82 After Gunnery (II)
Training good or very good	23%	40%
Training borderline	42%	44%
Training bad or very bad	34%	16%

The pattern of responses indicates that first of all the proportion of loaders and drivers who viewed training as borderline in terms of adequacy at the end of the two phases was about equal. Furthermore, the number who judged the training to be good or very good almost doubled in Phase II as compared with Phase I, while the proportion viewing the training as bad or very bad at the end of Phase II was about half that of Phase I. Still in all, 76% of drivers and loaders judged the training in Phase I to be borderline or worse, while 60% were of the same opinion at the end of the gunnery phase.

An attempt was made to identify areas where crewmen viewed their abilities as borderline or worse, and where they saw the need for additional training. Figure 9 presents ratings of loader abilities by both loaders,

and by TC's and gunners, in terms of the proportion of each group who rated loader capability as borderline or worse on each of the areas requiring loader proficiency.

As indicated by this figure, TC's and gunners generally had a higher opinion of loader skills than did the loaders themselves. Significant problem areas as seen by both groups include:

- alignment of laser range finder
- recoil mechanical check
- M73-M85 mechanical training
- grenade launcher operations
- emergency fire procedures
- system self test and verification
- missile misfire procedures

The two groups (loaders, and TC's & gunners) were also asked to identify which areas require additional training to successfully transition from an M60A1 loader to a loader in the A2. The results are presented in figure 10. As seen in this figure TC's and gunners generally think that loaders need more training than do the loaders themselves.

Areas receiving the highest ratings for additional training requirements were:

- system self test and verification
- alignment of the laser range finder
- grenade launcher operations

Similarly, driver skills and additional training requirements were rated by drivers on the one hand, and TC's and gunners on the other. The results are contained in figures 11 and 12. As the case with loaders, drivers had a poorer opinion of their own abilities than did TC's and gunners (Figure 11).

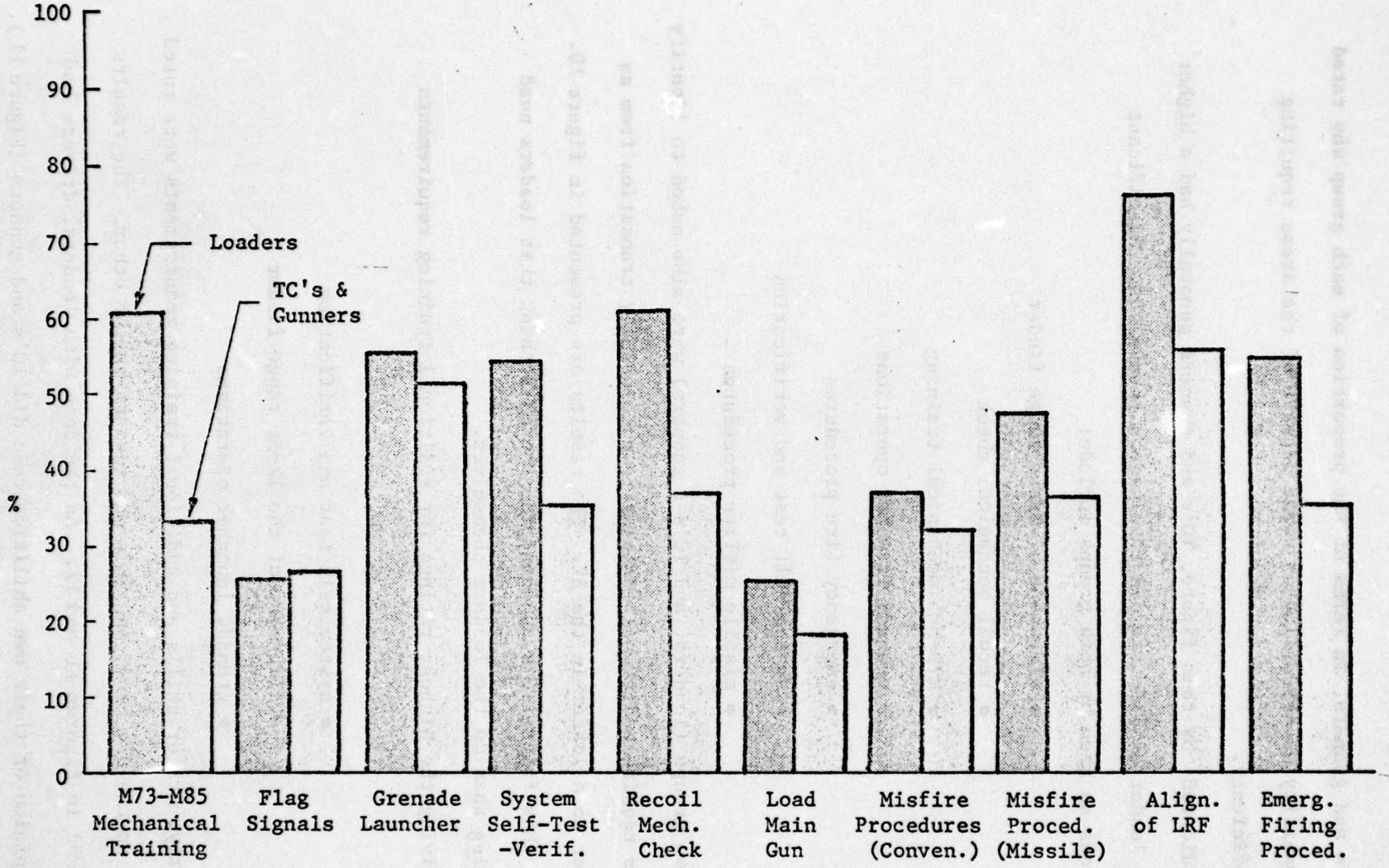

FIGURE 9. Ratings of Loader Skill Levels - by Loaders (n=43) and by TC's and Gunners (n=100) at the E of Gunnery (Phase II) - Proportion Rating Loader Ability as Borderline or Worse

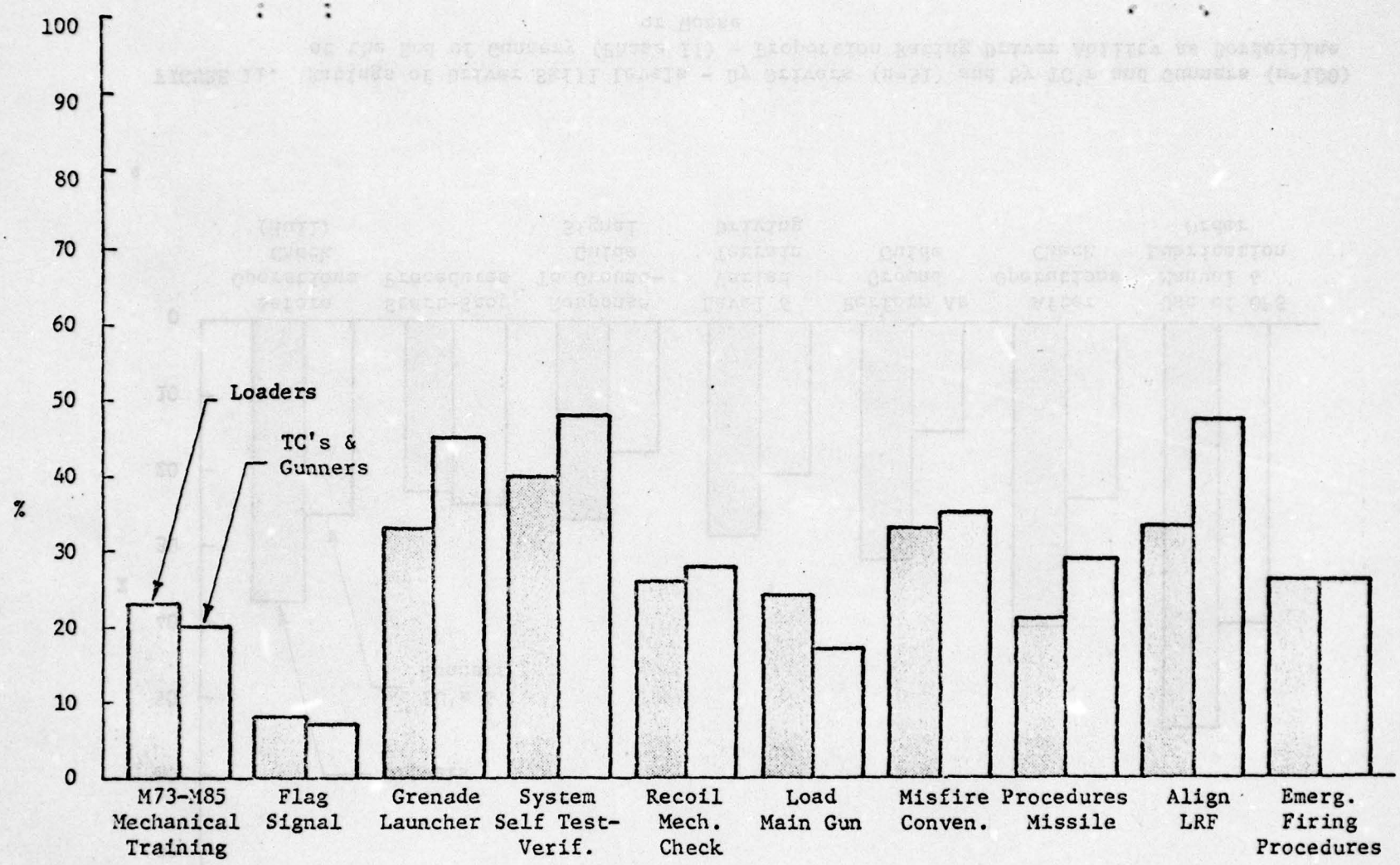

FIGURE 10. Proportion of Loaders (n=43) and TC's and Gunners (n=100) Who Feel that Loaders Need More Training Time to Successfully Transition from the M60A1 to the A2

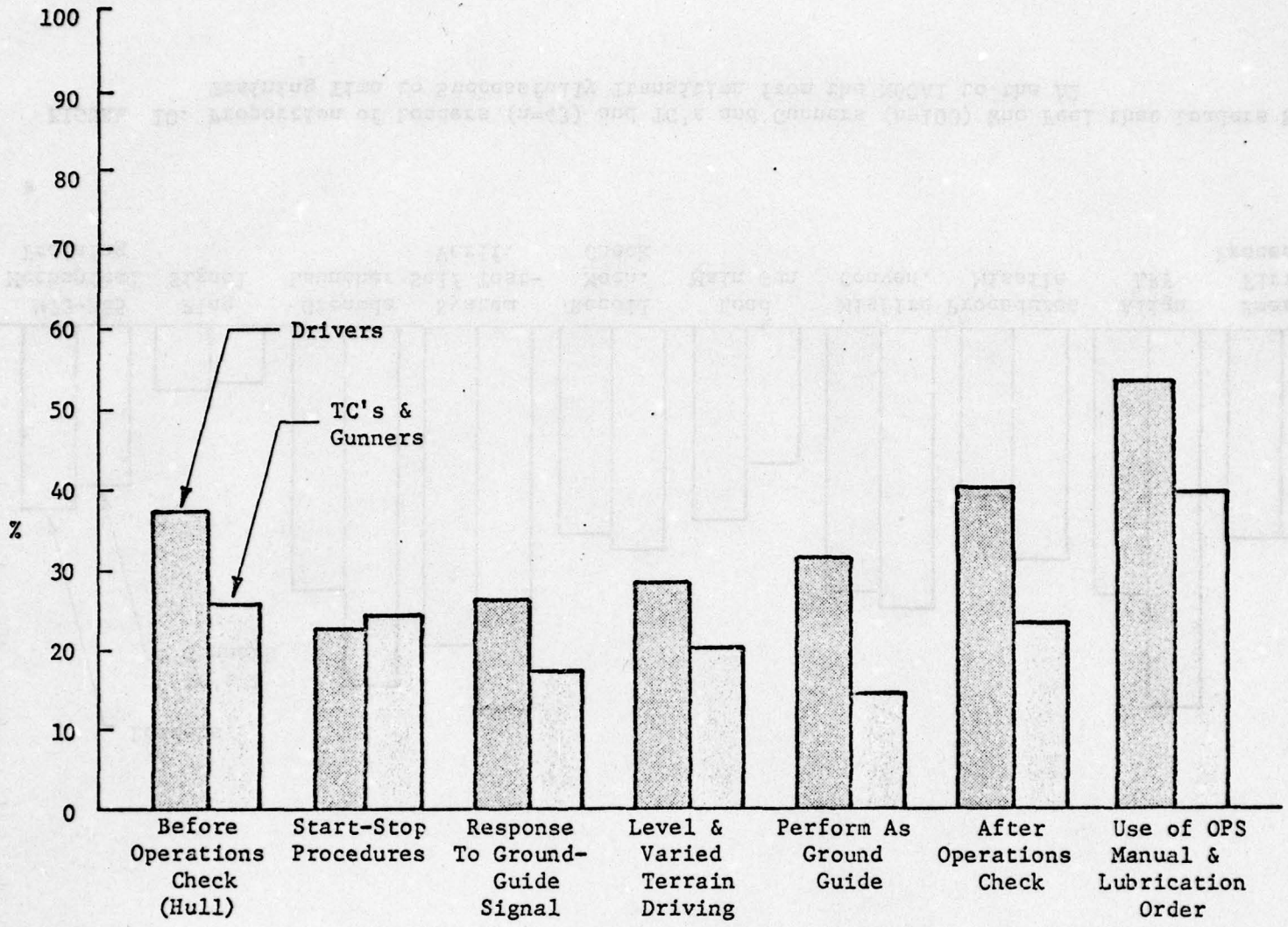

FIGURE 11. Ratings of Driver Skill Levels - By Drivers (n=51) and by TC's and Gunners (n=100) at the End of Gunnery (Phase II) - Proportion Rating Driver Ability as Borderline or Worse

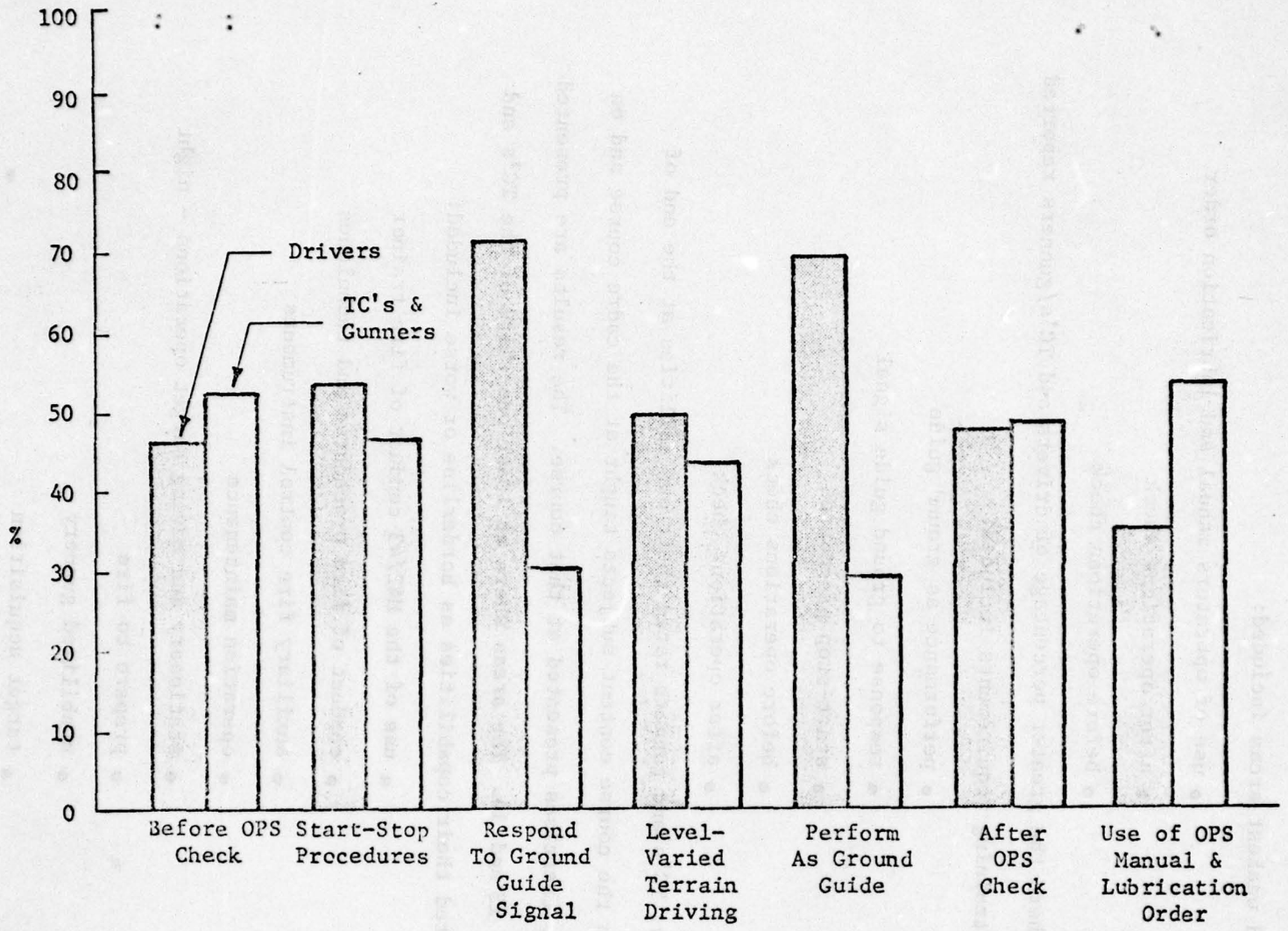

FIGURE 12. Proportion of Drivers (n=51) and TC's and Gunners (n=100) Who Feel That Drivers Need More Training Time to Successfully Transition from the M60A1 to the A2

The reported weakest areas included:

- use of operators manual and lubrication order
- after operations check
- before operations check

Areas where the greater percentage of drivers and TC's/gunners reported additional training requirements included:

- performance as ground guide
- response to ground guide signal
- start-stop procedures
- before operations check
- after operations check

Finally, TC's and gunners rated their own abilities at the end of Phase II on the course content subjects taught at the cadre course and on the gunnery exercises presented at that course. The results are presented in figures 13 and 14. The areas where at least one-third of the TC's and gunners rated their capabilities as borderline or worse included:

- use of the M42/43 conduct of fire trainer
- conduct of fire procedures and techniques
- auxiliary fire control instruments
- operation maintenance
- stationary and moving target operations - night
- prepare to fire
- stabilized gunnery
- target acquisition
- armament controls and equipment

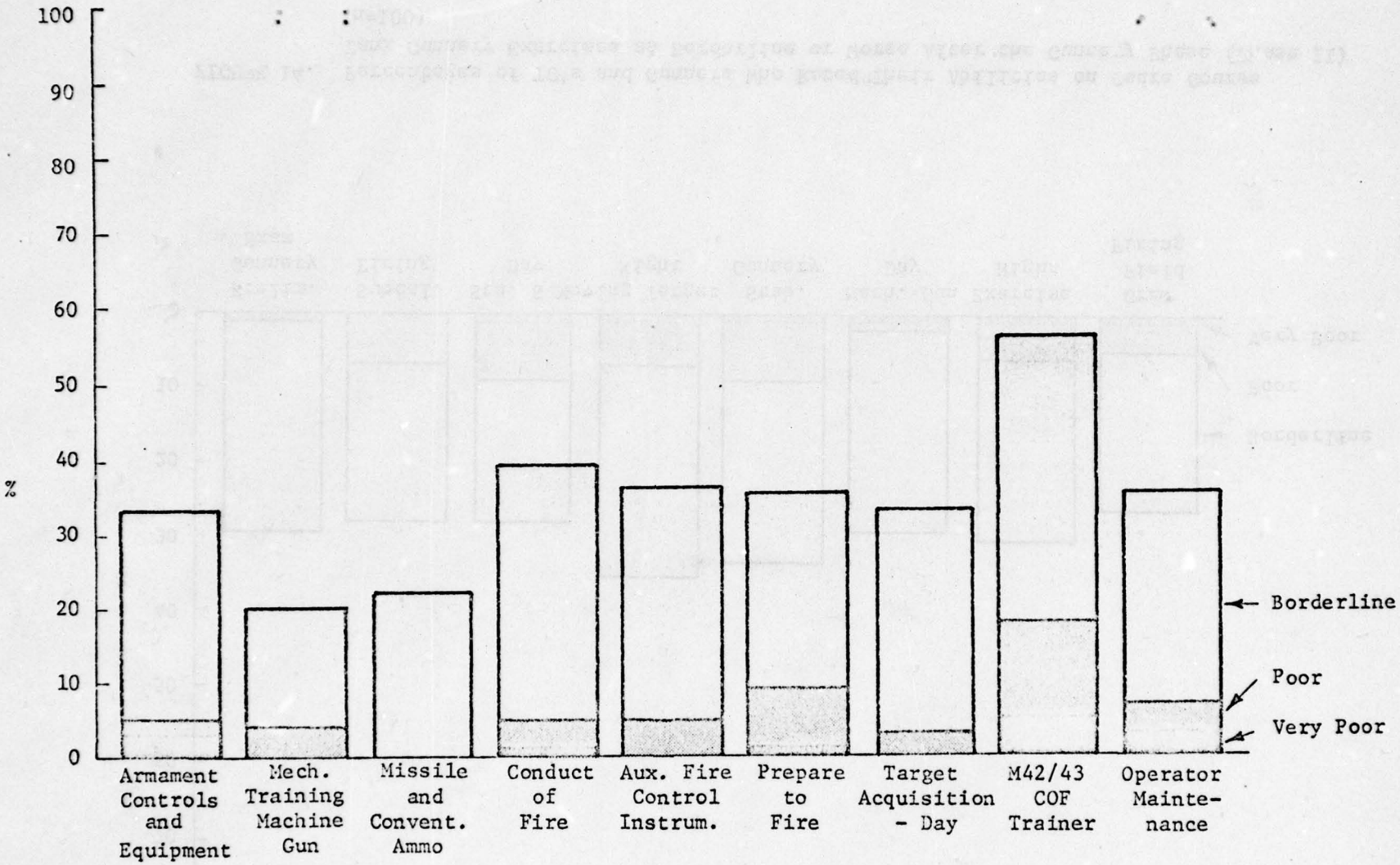

FIGURE 13. Percentages of TC's and Gunners Who Rated Their Abilities on Cadre Course Subject Areas as Borderline or Worse After the Gunnery Phase (Phase II) (n=100)

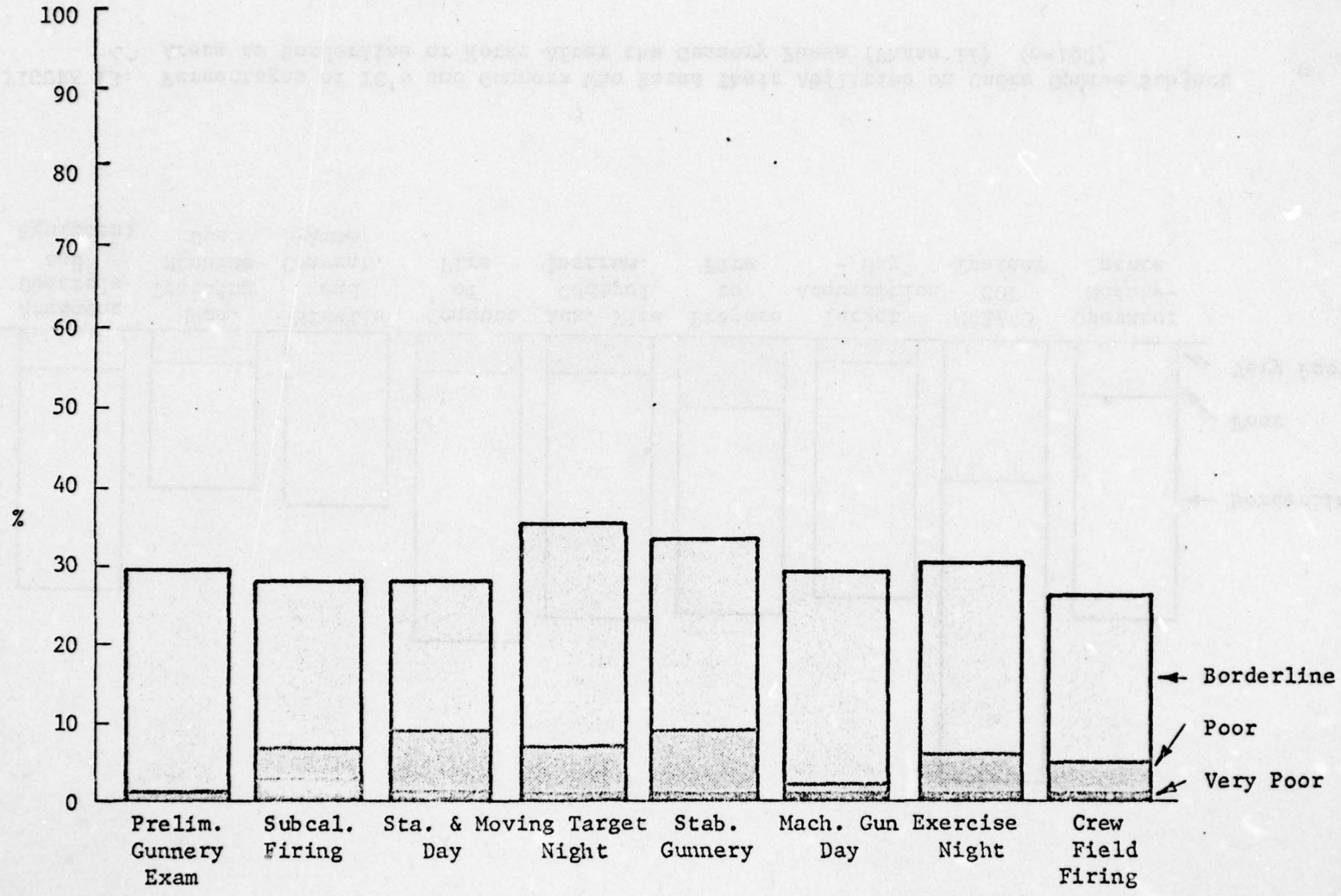

FIGURE 14. Percentages of TC's and Gunners Who Rated Their Abilities on Cadre Course Tank Gunnery Exercises as Borderline or Worse After the Gunnery Phase (Phase II) (n=100)

3.2.2.3 Conclusions and Problems - Tank Crew Training

1. Cadre Training

- Insufficient time in the Cadre Course was allocated to instruction and practice in areas directly related to gunnery and operator maintenance.
- Additional hands-on equipment time is inadequate in the Cadre Course. Practice time should be added to the course rather than simply reallocating time from classroom instruction to practical application.
- Training aids should be of sufficient quantity to enable an allocation of two students per aid.
- Tank Commanders required but did not receive instruction on turret maintenance in the Cadre Course.

2. Individual Training of Loaders and Drivers

- Insufficient training time allocated for classroom instruction, practical exercises, and hands-on equipment.
- Inadequate coverage is provided for all subjects.
- The training of loaders was inadequate in the following areas:
  - basic tank gunnery
  - reduction of weapon malfunctions
  - ammunition preparation
  - identification, stowage, and maintenance of ammunition
  - crew maintenance
  - tank weapon loading
- The training of drivers was inadequate in the following areas:
  - techniques of fire adjustment
  - range determination
  - operation of firing mechanisms
  - misfire clearance
  - tank loading

- ammunition characteristics
- tank nomenclature
- tank operation

- The sequencing of course material and time allocation to subject matter was not flexible enough to accommodate different requirements of different trainees.
- Instructors (TC's and gunners) were not trained in how to effectively plan and conduct instruction classes.
- There was little consistency across instructors in terms of instructional methods and use of visual aids and handouts.
- Training time was directly influenced by tank availability. Consideration should be given to development of trainers which would enable early crew training independently of tank status.
- No measures of performance were made during individual training. Thus the loaders and gunners were not informed of their progress or of their weak points.

3. Gunnery Training

- One of every two crewmen (n=179) were of the opinion that gunnery training was inadequate
- Insufficient time is allocated to all gunnery subjects
- Gunnery training prior to entry into the tank tables was not formalized or standardized
- Crewmen were not trained as a crew throughout the gunnery phase
- Instruction during gunnery was inadequate. Such instruction needs to be formalized and standardized.
- Lesson plans are not standard
- Insufficient use was made of handouts
- The preliminary gunnery exam was not an effective measure of crew skills, nor does it effectively assist the crewmen in identifying weak areas.
- Emphasis should be placed on gunnery throughout the training program and not merely after the company ATT's.

- The conduct of fire trainer was generally not available
- The course coverage and time allocated to the following was insufficient to effectively train loaders:
  - range finder alignment
  - recoil mechanism check
  - M73-M85 mechanical training
  - grenade launcher operations
  - emergency fire procedures
  - system self test
  - missile misfire procedures
- For drivers the areas of inadequate course coverage and time were:
  - use of operators manual
  - before/after operations check
  - ground guide operations
  - start-stop procedures
- For TC's and gunners the inadequately covered areas included:
  - use of M42/43 conduct of fire trainer
  - conduct of fire procedures and techniques
  - auxiliary fire control instruments
  - operation maintenance
  - stationary and moving target operations at night
  - prepare to fire procedures
  - stabilized gunnery
  - target acquisition
  - armament controls and equipment

3.2.3 Maintenance Training Evaluation

3.2.3.1 General

The primary problems noted with maintenance training involved deficiencies in manuals, availability of personnel, and availability of spare parts and supplies to a greater degree than problems with the training as such. A total of 66 maintenance personnel were surveyed at the conclusion of Phase II of the ICTT concerning their opinions and insights concerning M60A2 tank training. The MOS distribution of these personnel was as follows:

MOS	Number of Respondants	% of Total
41C Fire Control Repairman	8	12%
45K Tank Turret Repairman	9	14%
45R Turret Mechanic	12	18%
63C Tracked Vehicle Repairman	21	32%
Other	16	24%

3.2.3.2 Results and Discussion

A sampling of the opinions of these personnel concerning the maintenance training they received on the M60A2 tank includes the following:

The training coverage was borderline or worse for:

- 50% (3 of 6) of the 41C personnel
- 33% (2 of ç) of the 45K repairman
- 8% (1 of 12) of the 45R personnel

A total of 42% (27 of 64) of the maintenance personnel rated their own ability to accurately and quickly diagnose malfunctions as marginal or poor, at the end of Phase II.

Manuals are seldom or never used during a repair operation by 44% (28 of 62). 34% of the personnel (21 of 62) reported that a sufficient number of manuals was not available to support maintenance activities.

Based on responses to questionnaires at the end of Phase I, the overwhelming opinion of maintenance supervisors and technicians was that the training at Ft. Knox, Kentucky was very good or good; however, additional "hands-on" training was seen to be required to really familiarize personnel with the system. This was further borne out by the response of the supervisors to one of the questions concerning improvement of the technician's performance with experience. Thirty-eight percent (38%) of these supervisors stated that the improvement was considerable while (52%) stated that some improvement had occurred. This would seem to indicate that while the training provided was satsifactory, it did not go far enough. Some improvement is to be expected as personnel become more familiar with the system; however, additional training, especially on portions of the system which are entirely new, should be considered. This training could be conducted on mock-ups designed specifically to perform this function or as "hands-on" training prior to releasing the technician to the field. Ten percent (10%) of the supervisors stated that no improvement was noted with experience.

Twenty percent (20%) of the supervisors stated that CBSS training was very bad or bad, while 38% (6 of 16) 63C personnel rated the CBSS training as borderline or worse. Early in the M60A2 test program, an Evaluator Comment Sheet was generated which stated that the CBSS training was conducted at Fort Hood strictly to familiarize personnel on removal of the tank power pack with the CBSS attached. There were no handouts, training classes were large (e.g., company size), personnel constantly left the classroom to attend

to other duties, etc. The negative remarks are most likely based on these conditions. In order to be effective, classes should be organized to optimize the instructor/pupil ratio, instructors should organize their materiel and have handouts available, and personnel attendance should be scheduled to eliminate or minimize the impact by other duties on training.

When asked if 63C mechanics had an adequate knowledge of the closed breech scavanger system, each CO answered in the affirmative. One elaborated that more training time than the current eight hours are required on the CBSS.

New training aids should be available where required, and in sufficient quantity to allow all students in the class an opportunity for use. One of the more common responses to the questionnaires was that the training aids used by personnel at Fort Knox were adequate but there was not a sufficient quantity of these available. At Fort Hood, the quality and quantity of training aids were insufficient to meet the training requirements.

Interviews with company commanders indicated that in their opinions turret mechanics (MOS 45R) had adequate knowledge in their area of speciality. One commander stated that while his mechanics could identify that something is wrong, they need a troubleshooting chart to isolate the malfunction.

A survey of maintenance supervisors at the end of Phase II revealed that motor sergeants were not trained in the M60A2 and that they have experienced difficulty in supervising maintenance. The sergeants feel that formal maintenance training on the A2 systems is mandatory. The maintenance supervisors also observed that the special training on test and diagnostic equipment was insufficient and inadequate. In addition to training

problems, they also cited difficulties with the manuals, which they feel are incomplete, and with the test equipment which they think lacks the sophistication required.

3.2.3.3 Conclusions - Problems Identified for Maintenance Training

- Manual availability to support maintenance training was inadequate
- Personnel had to perform routine military activities as well as attending maintenance training exercises, which impairs their attendance at courses and reduces study time
- Tank unavailability interfered with hands-on time
- CBSS training was not formalized or standardized
- The number of training aids was inadequate

3.3 Crew Procedures

3.3.1 General

One general problem area of interest in the human factors evaluation of the M60A2 tank systems involves the operational procedures used by the tank crew. The evaluation of procedures is closely allied to the evaluation of tank systems design (the hardware associated with the procedures), technical and operations manuals, and training (wherein procedures are learned).

Problem areas identified for procedures involve the following:

- Communications procedures
- Preventive maintenance procedures
- Safety procedures
- Ammunition loading procedures
- Operational procedures

3.3.2. Results and Discussion

Communications

A copy of the Field Standard Operating Procedure (SOP) was obtained and reviewed to determine what the procedures are for precombat operations, tactical road marches, air attacks, ground attacks, occupation of assembly areas, night defensive positions (NDP's), delaying actions, etc. The intent of this review was to compare observed (including monitoring of radio networks) operations against the SOP. One of the primary items noted was that there is no specific communications procedure other than that the platoon leader is required to report crossing of checkpoints, phase lines, enemy contact, including air and observation. Also, loss of vehicles and changes in the tactical situation are to be reported during offensive operations. There is no SOP designating acceptable terminology, identification or authentication of commands, intra-tank communications, etc. Frequently, experienced T.C.'s communicate within the platoon and company adequately,

however, there are frequent lapses in proper communications procedures. Sometimes required communications are not transmitted to the proper authority at all; other times transmissions are late. It has also been noted that adequate and rapid transmission of data or information is necessary for satisfactory completion of a mission.

A questionnaire was administered to all crewmen concerning communications system design and procedures. This questionnaire was given at the end of Phases I and III in order to identify crewman knowledge of procedures as well as to determine changes in this knowledge from Phase I through Phase III.

The responses to questions from the communication questionnaire which dealt specifically with procedures, for the two phases, are presented in table 1. As indicated in this table a large proportion of crewmembers are still uncertain of the existence of SOP's even after Phase III of the ICTT. No changes were observed in the use of standard communication procedures from Phase I to Phase III, and in both phases more than half of the crewmen sampled stated that a standard procedure for communications is not used or only sometimes used.

The crewmen were also uncertain of the source for a standard communication procedure after Phase III, with about 25% (of 153) stating that they didn't know, and almost 30% believing that it came from custom and from SOP.

About 25% of the crewmen at the end of Phase III were still uncertain if checklists were available for standard modes of operation. Only a little less than half said that they were.

TABLE 1

Crew Responses to Communication Procedures Questions
at the end of Phases I and III

Question and Alternative Responses	Proportion of crew men responding (%) Phase I N=145	Phase III N=153
Do units have voice communication SOP's regs, etc.?		
Don't know	54	45
No	7	10
Yes	39	45
Is a standard voice communication procedure used in your tank?		
No	20	20
Sometimes	32	33
Yes	48	47
What is the source for the procedure?		
Don't know	32	24
Custom	30	32
Regulation	15	15
SOP	25	32
Are checklists available for all standard modes of operation?		
Don't know	33	26
No	28	26
Yes	39	48

Preventive Maintenance Procedures

Minor problems and breakdown have occurred during the test which have led to speculation that daily preventive maintenance procedures such as checking oil and hydraulic fluid levels, etc., were not being used or being used inadequately. This has shown up in daily maintenance logs and status forms. Lack of daily or periodic preventive maintenance or maintenance poorly or inadequately performed by the tank crew will lead to unnecessary down time. It may also deadline a tank on a battlefield.

Additional problems for crew maintenance are more attributable to deficiencies in training and manuals rather than to procedures as such. One problem is the inability of tank crewmen to isolate malfunctions in the field. The tank commanders from each company were asked how often were they able to determine the cause of a problem. Their unanimous response was, never. The TC's further indicated that crew members generally know how to use manuals for operational checks but that they seldom do, mainly due to the inconvenience associated with using the manuals. When asked how long would it take to perform a PM check as outlined in the manual, the TC's estimated up to 8 hours. They state that the manual is cumbersome and that it is hard to find things in it. Some checklists used for PM checks are too long and complicated. Some of the checks cited by the manual as being required on a daily basis are not so required, in the opinion of the tank commanders.

Tank commanders also recommend reallocation of maintenance tasks to give the crew more responsibility in troubleshooting and simple field adjustment and repair.

Another item to be reported under procedural problem areas concerns re-installation of equipment after testing. A test performed on the gunner's

periscope required that the cable to the periscope be disconnected and later re-connected. It was not re-connected and the connector subsequently became enmeshed in the turret drive gear and was destroyed as the turret rotated. It was not determined if there are specific procedures to cover these maintenance operations; however, one must assume that they existed and were not followed nor were adequate post-maintenance checks performed.

The requirements in the preventive maintenance area therefore are a reallocation of tasks to give the crew more responsibility (and attendant skills) in field maintenance, and standardized PM procedures structured in an easy to use checklist.

Safety Procedures

Tank commanders interviewed at the end of Phase II stated that adherence to safety procedures need to be improved, and that more emphasis must be given to safety during training. The objective should be to make the crewmen constantly safety conscious. As an illustration, it was reported during a MASSTER briefing that safety procedures were being violated during removal of equipment; specifically the gunners' periscope. This violation occurred at battalion level when the periscope was lowered from its position onto the lap of one of the maintenance personnel rather than with the fixture provided for this purpose. Injury to personnel could result from such actions.

Ammunition loading Procedures

The failure to use the appropriate procedure to load ammunition revealed problems during the full combat-load test. In one observed case, the TC loaded all his missiles and then began loading the conventional rounds. When he attempted to load the ready rack near the gunner's foot, he discovered that the rounds could not be loaded. This necessitated unloading

three missles before another attempt could be made. The TC never referred to the Operations Manual TM9-2350-232-10 pages 4-19 through 4-22. These pages indicate in pictorial fashion as well as text where ammunition is stored in the tank. This manual does not indicate the appropriate or most efficient sequence for stowage.

The problems of maintenance and ammunition stowage, as well as some others, could be minimized by the use of checklists or decals displayed prominently in the vehicle. If used, these should be brief and concise and very clear. One line reminders with the task and expected display or result would serve well. Where a given sequence is optimum, the steps should be clearly numbered. For example, in stowing ammunition a checklist could read as follows:

1 Remove missile pods (2 or 3) in front of lower right ready rack

2 Load ready rack

3 Replace missile pods, etc.

The corresponding numbers on the checklist should appear on the diagrams as an aid in indicating the appropriate referenced location.

Operating Procedures

The survey of communications procedure problems indicated that voice communication SOP's are either non existent or non available to a large proportion of crewmen. This situation was observed thorughout M60A2 operations and was not confined to the communications area.

Tank commanders, gunners, and loaders were asked to what degree does their tank interact with other tanks to spread the number of targets among the tanks. The responses, by duty position, in terms of percentage giving

each response were:

Response	Percent Responding TC	Gunner	Loader
Never	28 %	25 %	50 %
Occasionally	47	41	33
Whenever Possible	17	27	8
Always	9	6	8

The results indicate at least two deficiencies in standardized procedures. First of all, crewmen do not agree on the frequency with which a tank attempts to interact with other tanks to allocate targets, since proportionately twice as many loaders felt that it was never done as compared with gunners. Secondly, it seems that a standard procedure does not exist, or that the crewmen generally are not aware of it, or they are aware of it but do not follow it.

Crewmen were asked to evaluate the procedure used for alerting the TC of a target when that target is detected by another crewmember (other than the TC). The responses of TC's, gunners, and loaders were as follows:

	TC	Gunner	Loader
Procedure not available	27%	17%	53%
Procedure available but inadequate	10	13	13
Procedure is of borderline adequacy	14	24	13
Procedure is adequate	22	22	11
Procedure is very good	27	24	11

Once again a proportionately greater number of loaders are not aware that there is a procedure as compared with TC's and gunners.

TC's and gunners were asked what is the procedure to be used when they suspect a laser range finder malfunction. Responses were as follows:

	TC	Gunner
Rely on visual ranging	16%	6%
Gunner repeat ranging	40	31
TC repeat ranging	30	33
Check circuit breakers-systems	12	36

These responses indicate that either no clear standard operating procedure exists or that crewmen are not aware of an SOP to assist them in making decisions of what to do next in the event of a laser range finder suspected malfunction.

In interviews after Phase II, TC's and company commanders were asked to identify what procedures, if any, should be standardized and incorporated into an SOP. The list of identified operations was as follows:

- stabilization system operations - when to use it, etc.
- require that the engine be running when turret power is required
- standardize the frequency of CBSS checks
- use a dipstick to check turret fluid levels rather than a visual estimation of fluid quantity
- target engagement techniques
- carry position
- simplified and standardized prepare to fire checks
- standard uniform
- minimum acceptable crew size for training (should be 3 rather than 2 crewmen)
- restrictions on wearing binoculars around the neck
- provision for using a hand microphone or loudspeaker
- battle sights
- precombat checks
- frequency of system exercise
- missile subsystem checks

Summary

The primary problem for procedures is the lack of standardized procedures. Ancillary problems include problems with manuals and check lists, dissemination of SOP's, and procedural training.

3.3.3. Conclusions - Problems for Crew Procedures

- There is no standardized communications procedure
- Maintenance procedures in the field are inadequate
- Adherence to safety procedures needs improvement, possibly through increasing the safety motivation of personnel
- Expanded use of improved checklists is required
- Standardization of all operating procedures and techniques is required

3.4 Evaluation of Manuals

3.4.1. Results and Discussion

Questionnaires presented to crewmen at the end of Phase II attempted to determine the frequency of use and adequacy of manuals. A total of 84% of 178 crewmen sampled indicated that they used the operator manual (TM 2350-2321-10), with 71 percent claiming that they use it daily or weekly.

A predominance of answers to the questionnaires indicated that the operator's manuals are frequently or constantly used. Actual experience based on direct observation reveals that this was not necessarily the case. There has been historically, a struggle to get personnel to use or refer to a manual for operations and/or maintenance tasks. The full combat load (Appendix D) test showed that most crews participating did not use the operator's manual nor follow the proper procedures listed in the manual.

Further, the tank crew survey responses stated that the illustrations in the operator's manual were not adequate for usage. This is also true of the method in which the manual is bound. The binding is standard for paperback manuals. These are difficult to keep open to the appropriate page without breaking the spine of the manual or back. A spiral or similar binding with end tabs or markers would prove more useful to the crew. This would save considerable time spent searching for a particular procedure or sequence of operations. Often used and critical crew operating procedures should be on separate moistureproof checklists.

Three maintenance manuals were rated as generally being inadequate across the board including clarity, completeness, accuracy, indexing, illustrations, task sequencing, and task allocation. These manuals are:

1 TM9-2350-232-20/1 Organizational Maintenance (Hull)

2 TM9-2350-232-20/2 Organizational Maintenance (Turret)

3 TM9-2350-232-20P Organizational Maintenance (Parts)

Concerning availability of manuals, one-third of both crewmen and maintenance personnel reported that sufficient copies were not available. An additional 31% of crewmen stated that the full allocation was not available at the end of Phase II while 23% stated that while the full allocation was available, more were needed.

The significant problems with the manuals include their size, indexing, format, illustrations, and binding. Numerous crewmen and maintenance personnel stated in interviews that use of the manuals was inconvenient and generally not worth the effort. As an example, the organizational maintenance manual for"TURRET, Elevating and Traversing Systems, Cupola, Gun/Launcher M60A2" TM9-2350-232-20-2 (April 1973) contains 700 pages of instructions, procedures, troubleshooting decision aids, and schematics for maintenance activities. The volume is difficult to use due to its size and the fact that the only index (by subject) is contained at the back of the book. Consideration should be given to breaking it up into several smaller documents, organized by functional requirements and by tank systems. Better methods of indexing must be developed which should at least include the use of tabs. Illustrations are usually difficult to find and, when in photograph form, difficult to interpret. Troubleshooting aids consist of a sequence of steps where, for long sequences, it is not unlikely that a user could overlook a step in the sequence. Consideration should be given to development of graphic troubleshooting aids indicating what should be done next on the basis of information obtained at each test point.

The current method of indexing is inadequate not only in its location but in its structure. If a technician wants the troubleshooting sequence for a grenade launcher and looks up grenade launcher in the index, he will not find any indication of troubleshooting procedures. He may at this point

decide (with some justification) that the manual contains no sequence for troubleshooting the grenade launcher. However, if he were to persevere, and look under Troubleshooting in the index, he would find grenade launcher troubleshooting and the page number for the procedures.

This brings up a problem of organization of the manual. The document is structured by maintenance function and then by system descriptions. Thus preventive maintenance, checkout procedures, troubleshooting sequences, and electrical schematics are given in four different sections across all systems. Then separate sections are devoted to system descriptions and data.

If a maintenance technician wants information on the CBSS, his initial problem is that he must flip a lot of pages of the index to find the desired section of the manual. No page numbers are associated with any subheading of the CBSS in the index. The indexing, as presented in the manual, is presented below:

Closed breech scabenge system

Block connector (see connector)

Data (see data)

Hoses (see hoses)

Inject promimity switch (see switch)

Inject proximity switch actuating magnet (see magnet)

Inject solenoid valve (see valve)

Inject solenoid valve mounting bracket (see bracket)

Low pressure warning switch (see switch)

Main gun inject plunger assembly (see plunger)

Swivel joint (see joint)

Tubes (see tubes)

If the technician wants information on the CBSS proximity switch, he is

sent (from the switch listing) to page 2-655. If he wants CBSS troubleshooting procedures, he goes to page 2-142. For qualification procedures on the CBSS he must go to 2-118, and for the schematic of CBSS electrical connections (for which no reference exists at all in the index) he goes to page 2-431. The manual would be more useful, usable, and meaningful to this technician if all CBSS material was located at one place in the manual.

3.4.2. Conclusions - Problems with Technical manuals

Problems with manuals included:

- The unavailability of sufficient manuals for individual crewmen, at Ft. Knox and Aberdeen schools, and at Ft. Hood
- Inadequate binding of the manuals
- The large size of the manuals
- Inadequate structure and location of manual indexes
- Inadequate organization of material in the manuals
- Inadequate illustrations, in terms of quality, content, and location with respect to relevant text

3.5 M60A2 Tank Systems Human Factors Design Evaluation

3.5.1. General

The M60A2 tank systems were subjected to a number of human factors analyses to identify specific problems with system design for:

design for operability - which includes evaluation of system ease of operation and effect of system design configuration on crewmen performance.

design for safety - the degree to which the tank system design configuration produces hazards to personnel safety.

design for maintainability - the degree to which the tank was designed to be easily and quickly maintained by crewmembers and maintenance personnel. Due to the problems encountered during the ICTT with maintenance supplies, only a minimal evaluation of design for maintainability was conducted.

As indicated in the study guidelines (section 1.0), while problem areas related to man-machine interface design were identified, recommendations for changes or redesign were formulated for those problems related to personnel safety.

3.5.1. Results and Discussion

3.5.1.1. Design for Operability

1) Gunner's Station

General Arrangement: The gunner's workstation was generally acceptable for the arrangement, layout, and accessibility of controls and displays within the station.

This was the most compact of the four crew stations. In that light, the station was down rated by the gunners with regard to workspace, seat comfort, seat adjustment, ride quality, ease of ingress/egress, and hand and footholds for standup operation (see Figure 15). The grouping of seat comfort, adjustment and ride quality was rated poorly because of the small amount of free volume in the station around the seat. The seat itself has been, in several interviews, stated to be the only crew position where the seat occupant is comfortable enough that he can relax. The poor ratings were more due to the space encroachment by structure in the gunner's seat area. For example, there are ammunition racks close by to the left; a long handled screw driver on the right that rubs the leg; the manual gun elevation pump handle and assembly under the left leg; and various protruding exposed bolt heads on controls. It is probable that it was those things in the seat area that were rated and not the seat itself.

The compactness of the station helped the location and use of the telescope and periscope to be rated acceptable. An item that could be a problem under certain conditions was having to view the elevation bubble through a mirror arrangement. The mirror became obscured by dust or by fogging. The manual operation

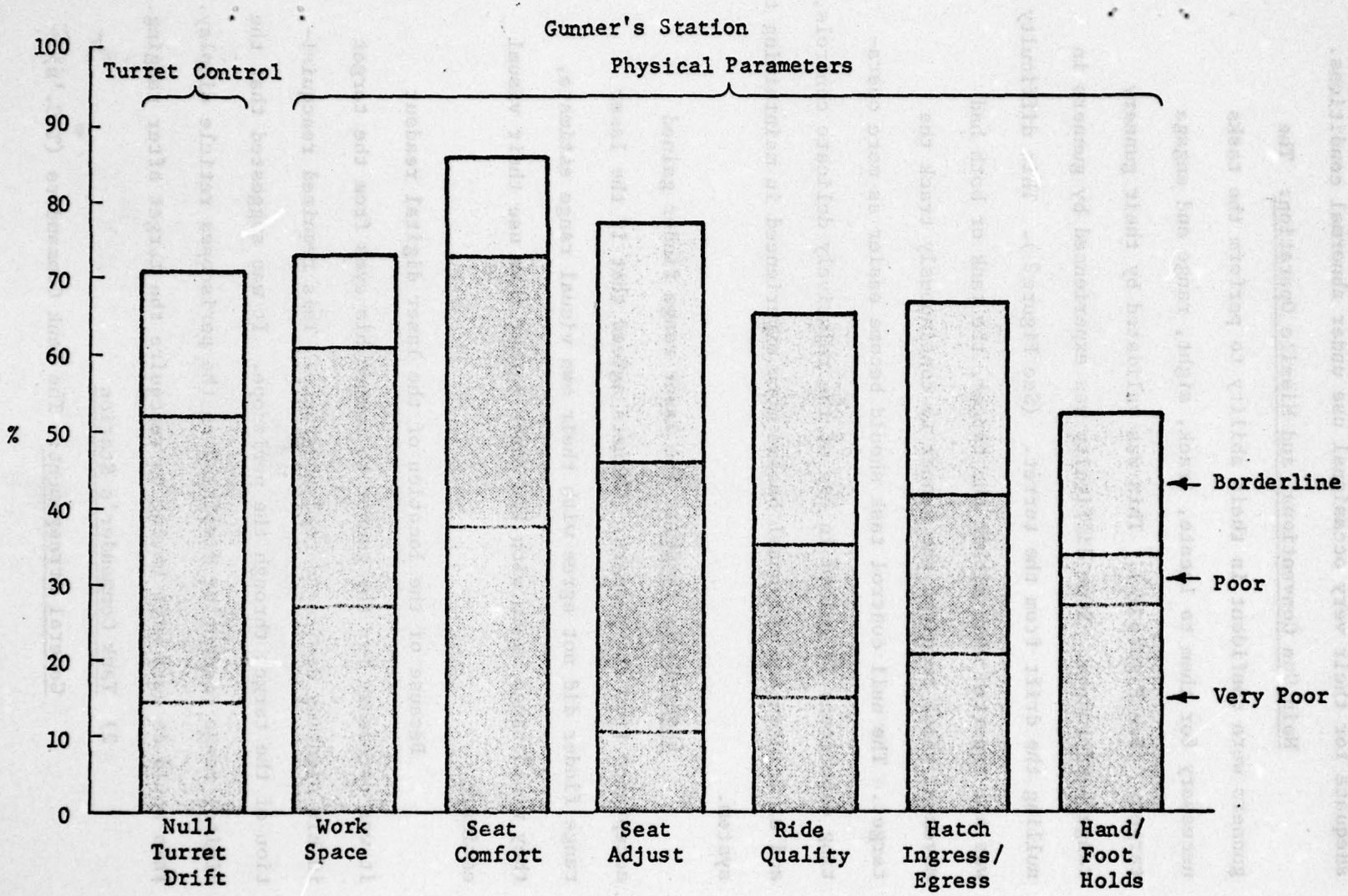

FIGURE 17. Gunner Ratings of the Physical Parameters of their Station (N = 48)

power controls are not optimally located, but were considered adequate for their very occasional use under abnormal conditions.

Main Gun Conventional and Missile Operation: The gunners were confident in their ability to perform the tasks necessary for them to locate, track, sight, range and engage target. (See Figure 16). This was validated by their gunnery range performance. Some difficulty was experienced by gunners in nulling the drift from the turret. (See Figure 2). This difficulty was not reported when either the target, the tank or both had movement which required the gunner to continuously track the target. The null control task should become easier as more operating experience is gained in use of the relatively delicate controls, and as maintenance personnel became more experienced in maintaining the system.

Laser-Range Finder: The laser range finder gained acceptance from the gunners. Gunners agreed that if the laser range finder did not agree with their own visual range estimate, they would range again with the laser rather than use their visual estimate.

Because of the location of the laser digital readout it was necessary for the gunner to remove his eyes from the target in his signting device to read the range. This required reacquisition of the target through the periscope. It was suggested that the digital range readout be displayed on the periscopes reticle display. This would do away with having to reacquire the target after ranging.

2) Tank Commander's Station

General Arrangement: The Tank Commanders (T.C.'s)

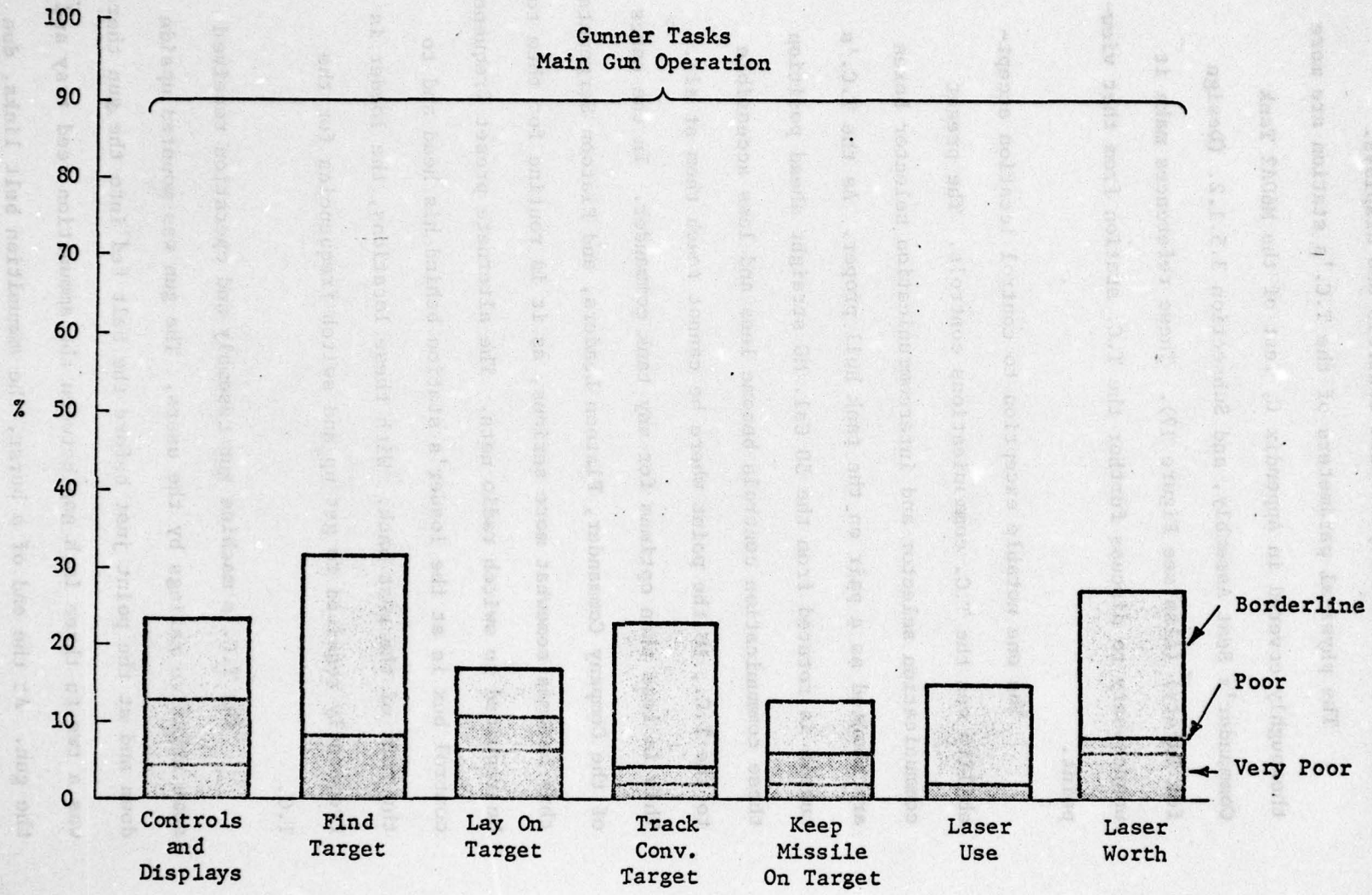

FIGURE 16. Percentage of Gunners (N = 48) who rated Gunnery operations as borderline or less.

workstation was generally acceptable for the arrangement, lay-out, and accessibility of most controls and displays.

The physical parameters of the T.C.'s station are more thoroughly covered in Appendix C, Test of the M60A2 Tank Commander's Seat Assembly, and Subsection 3.5.1.2. (Design for Safety) (Also see Figure 17). These references make it unnecessary to discuss further the T.C. station from that viewpoint.

The one notable exception to control location acceptability was the T.C. communications controls. The preset communication selector and intercommunication selector boxes are mounted as a pair on the tank hull proper. As the T.C.'s cupola is rotated from the 50 Cal. MG straight ahead position these communication controls become less and less accessible to the T.C., to the point where he cannot reach them at all. This is less than optimum for any tank commander. In the cases of the Company Commander, Platoon Leaders, and Platoon Sergeants, this becomes somewhat more serious, as it is routine for them to be required to switch radio nets. The alternate preset frequency control box is at the loader's station behind his head and to the rear of the seat back. With these locations, the loader is frequently required to get up and switch frequencies for the T.C.

The T.C.'s machine gun assembly and operation received some negative ratings by the users. The gun was mounted upside down and at the point just before the belt fed into the gun there was a two to three inch gap between the ammunition feed tray and the gun. At the end of a burst, the ammunition belt links, due

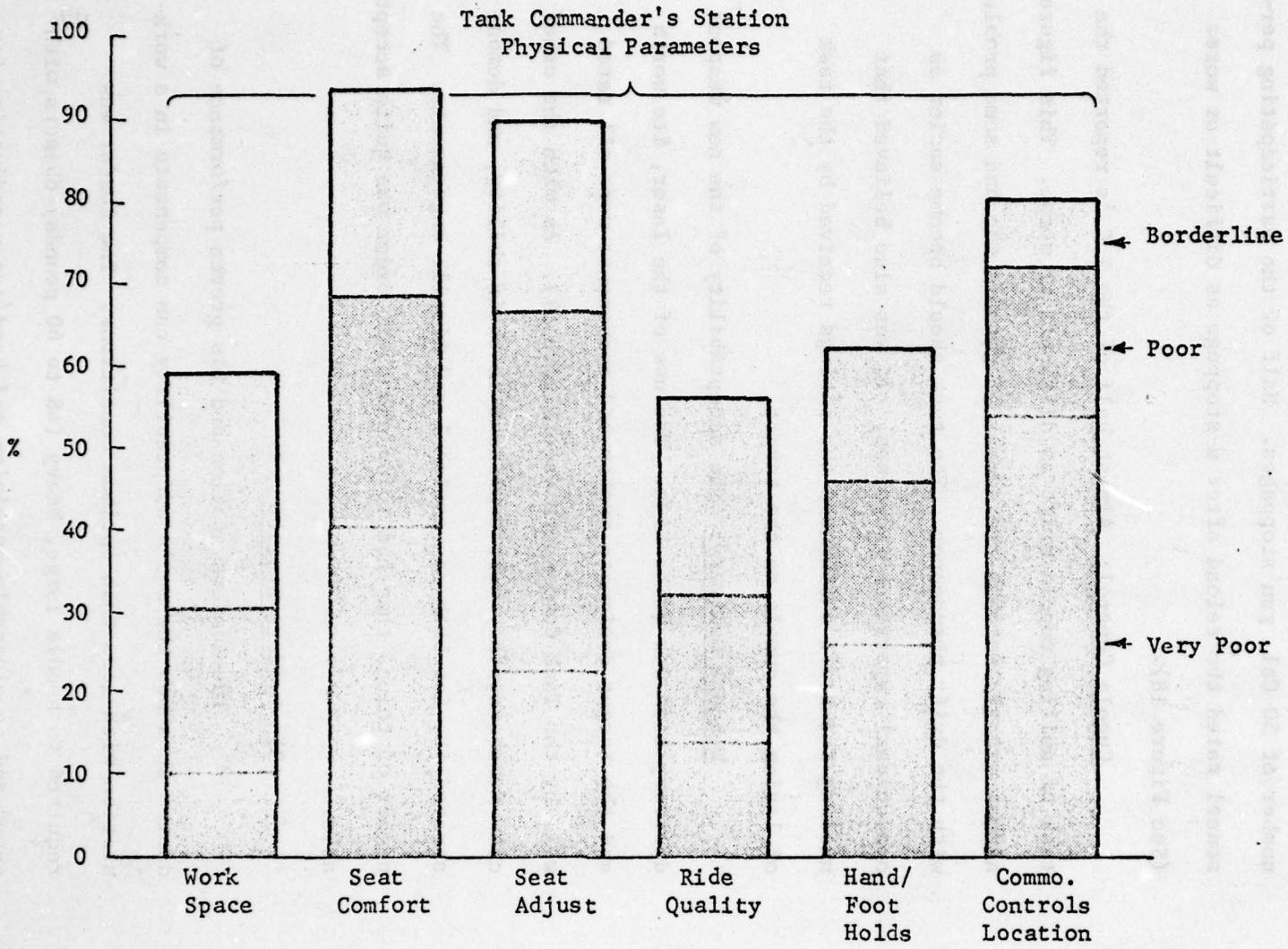

FIGURE 17. Tank Commander's Ratings of Their Workstations (N = 51)

to inertia, tend to try to buckle into this gap. For some unknown reason short bursts in particular tended to make the ammunition belt break at this point. This created higher than desirable number of 50 Cal. gun stoppages. Half of the participating personnel rated the reload after a stoppage as difficult or worse (See Figure 18).

Cupola Control: Almost half of the T.C.'s reported the task of nulling cupola drift as difficult or worse. This figure almost exactly matches the number of gunners who had some problem with the drift phenomenon. The task should become easier as operational experience increases. It was also believed that nulling the drift influenced the ratings received by the task of laying the cupola on the target.

Weapons Delivery: The acceptability of the new weapons delivery aids was quite high. The use of the laser, its worth and the target designate system and components were all rated well by the Tank Commanders (see Figure 19.). As with the other crew memebers, they were confident in their ability, and demonstrated it, for both conventional and missile engagements. The number of things they had to do and their order was quite acceptable.

3) Loaders Station

The loaders station and his proven performance of duties show how the man's adaptability can compensate in a workstation with less than optimum conditions. The loader was required to handle large, heavy (48 to 60 pounds) objects with speed and considerable precision and hand/eye coordination for successful preparation to fire the main gun. This was not always an easy task.

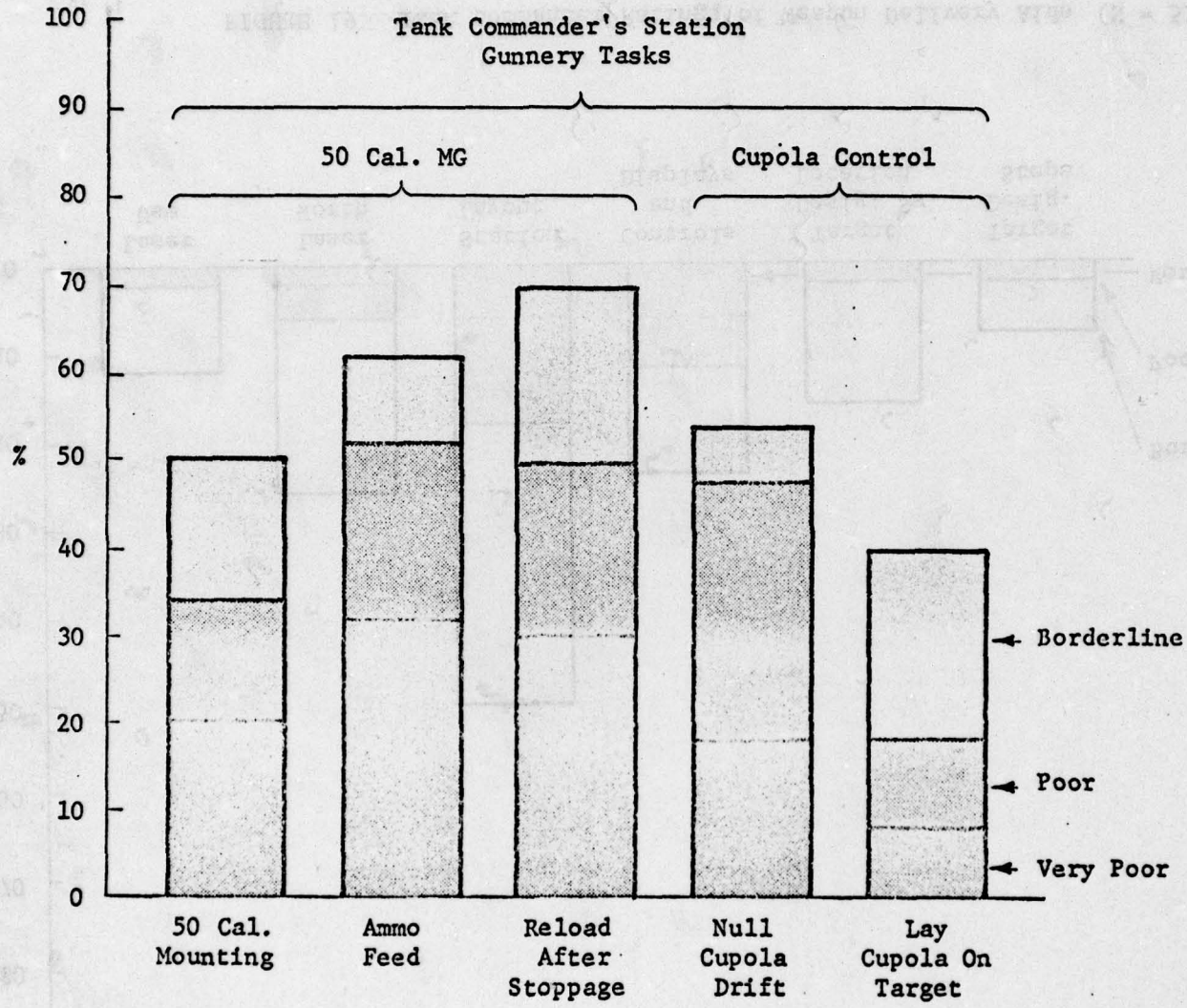

FIGURE 18. Tank Commander's Ratings of Gunnery Tasks (N = 51)

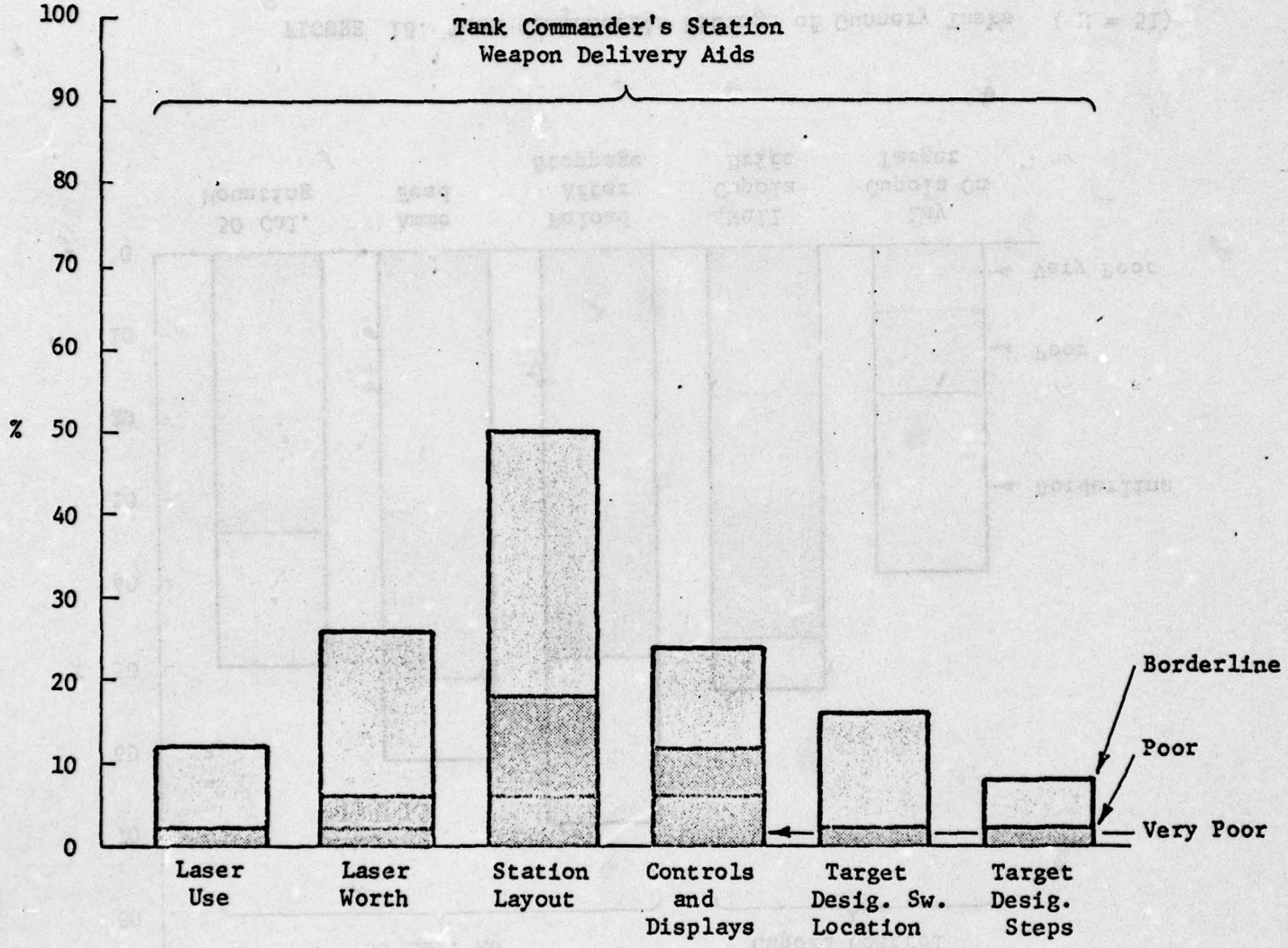

FIGURE 19. Tank Commander Ratings of Weapon Delivery Aids (N = 51)

General Arrangement

The general arrangement of the loaders station was rated unsatisfactory. He complained of being hampered by a lack of work space, and an uncomfortable seat with inadequate adjustment. The seat back/pan angle is acute and it is not possible to sit comfortably due to this. It also makes the seat backrest contact the back in a single, narrow pressure line. These may have influenced the mixed rating received by the ride quality of the tank. The standup operation hand and footholds were rated inadequate or unsafe by about one fourth of the loaders. They also report some difficulty entering and leaving the tank under varying conditions. The radio and intercom controls were located behind the loader's head and above and to one side of the seat back. This location required the loader to twist his body on the seat, or stand up and turn around to change the frequency selectors (see Figure 20).

Coax Machine Gun (MG)

The coax MG received negative ratings on the way it was mounted, the coax ammunition feed system, and reloading if after a stoppage. Some of the rating was due to having to reach and stretch to load the gun with complete access impeded by some fixed equipment installations.

Main Gun, Conventional and Missile

For a main gun conventional ammunition engagement the loaders were satisfied with their adequacy to operate the gun breech; peel the barrier bag from the round; the number of things they had to do; and the order in which they had to be done. Their adequacy was reflected by all crews successfully completing gunnery qualification, and a minimal number of very poor or poor loader ratings of them by their gunners and tank commanders

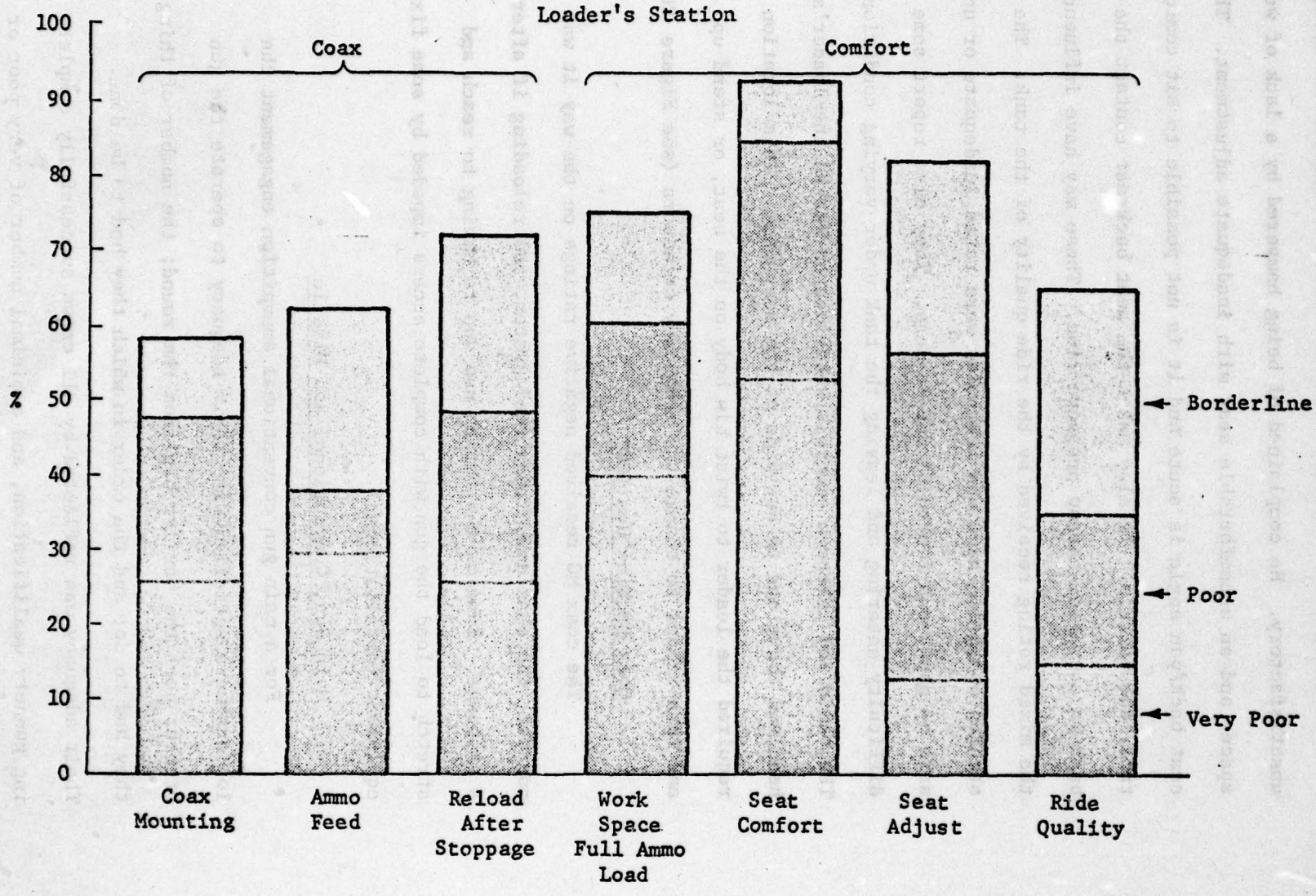

FIGURE 20. Loader Ratings of Workstation Parameters (N = 40)

(see Figure 21). A main gun missile engagement evoked the same general response pattern from the loaders as a conventional ammunition engagement. The peer ratings by the gunners and tank commanders also showed general satisfaction with the loader's performance of their duties. (see Figure 9).

4) Driver's Station

General Arrangement:

The arrangement of switches, displays, circuit breakers, etc., was rated as adequate or better by 78% of the drivers. The layout of controls and their accessibility was rated adequate or better by 57% (22) of the drivers. An additional segment reported having a problem only with some tasks, but these did not preclude mission completion. The location of the intercommunication control panel was rated as borderline or worse by a majority of the drivers. This location could be improved, but is not considered a serious problem as once the driver places the position selector to the desired receiving mode, it is not necessary to change the control for the remainder of the mission. The ride quality of the tank was rated as borderline or worse by many of the drivers. It is believed that much of this dissatisfaction is due to the problem discussed on the driver's seat (see Figure 22).

Comfort

The driver's seat assembly was rated by nearly all of the drivers as uncomfortable at least some of the time. The seat was continually uncomfortable to some degree to the major-

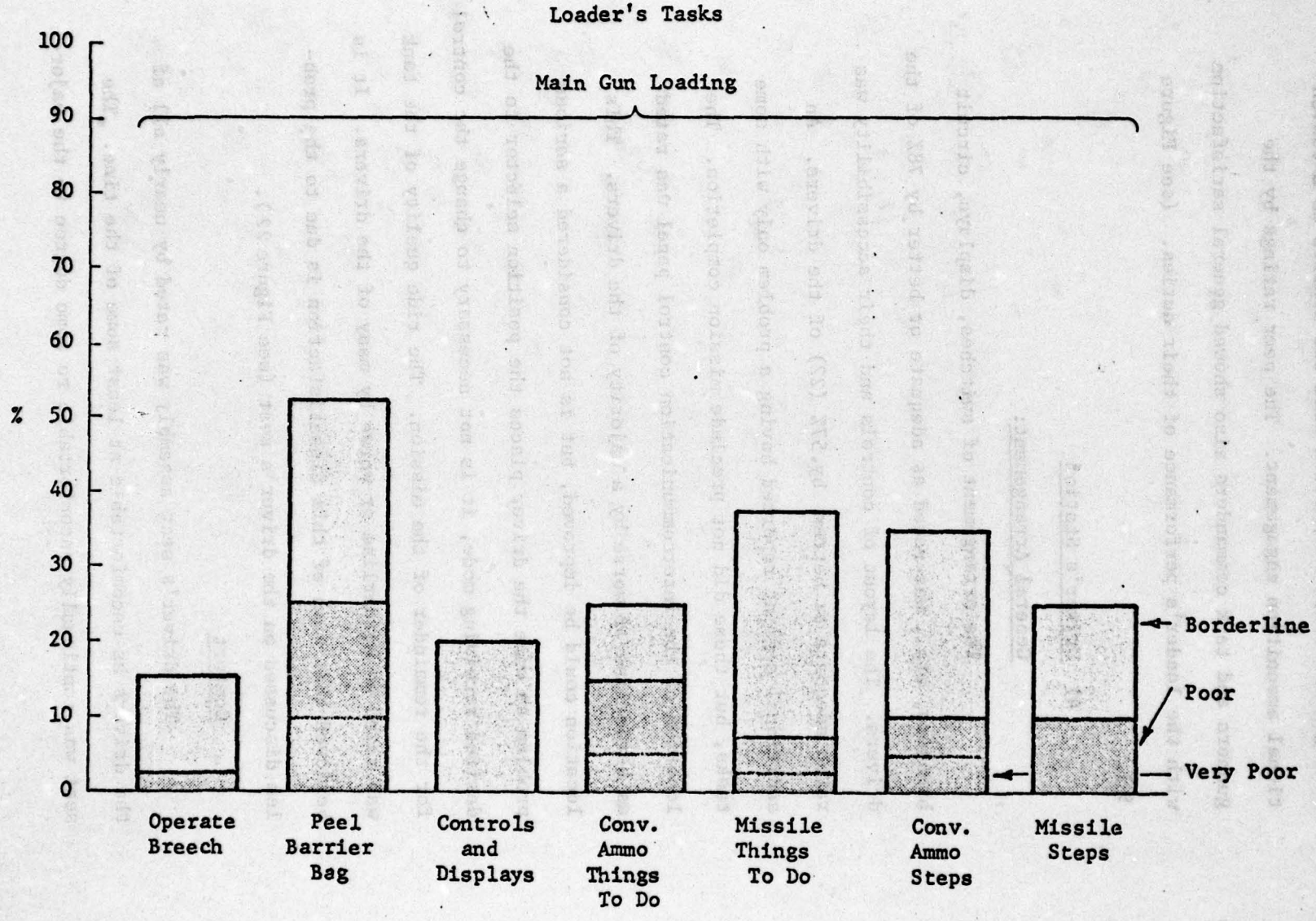

FIGURE 21. Loader Ratings of Main Gun Loading (N = 40)

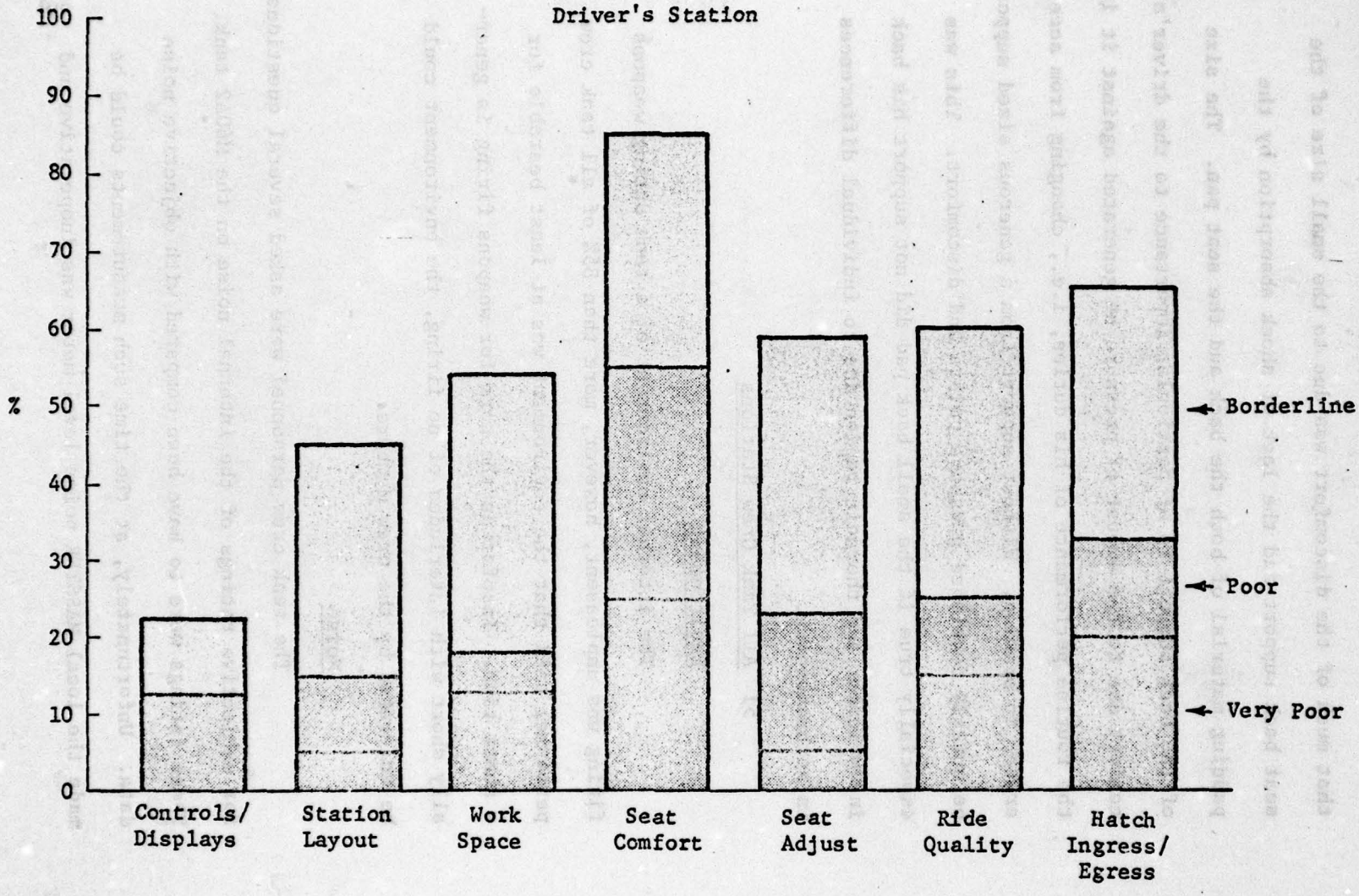

FIGURE 22. Driver Ratings of Workstation Parameters (N = 40)

ity of the drivers.

Investigation of these responses led to the conclusion that much of the discomfort was due to the small size of the seat back support and the lack of shock absorption by the padding material of both the back and the seat pan. The size of the back support is of particular importance to the driver's comfort due to the amount of pressure he generated against it in the routine performance of his duties, i.e., changing from accelerator to braking. Without support from a generous sized support, he quickly developed pressure points and discomfort. This was especially true if the small back pad did not support his back in the lumbar and thoracic region due to individual differences in anthropometry.

5) All Tank Crew Stations

Environment

The internal environment of a tank during weapons firing was unpleasant, however, more than 85% of all tank crew personnel said that the environment was at least bearable for a short time. Insofar as the norm for weapons firing is generally short with interludes of no firing, the environment could be tolerated by the crew members.

Noise

The tank crew personnel were asked several questions for subjective ratings of tbe internal noise on the M60A2 tank. These ratings were to have been compared with objective noise data. Unfortunately, at the time such measurements could be made the local MASSTER noise level meter was inoperative and

awaiting maintenance. No objective noise data were therefore obtained.

With the exception of the drivers, the general response that "Noise made communication difficult" or worse, was selected by about 20% of the responding personnel. (see Figure 23). Because the interphone must be used for nearly all intra-tank communication, even this is less than desirable. A total of 60% of the (40) drivers reported that tank noise makes communication difficult. (Figure 23) It is essential that each crew member be able to communicate quickly and understandably to the others in the crew. When asked "What is the reason you asked to have an interphone message repeated"? the response of "Noise level in the tank was too high" was selected by almost 38% of the personnel. This was almost 9% higher than the next most frequent response, which was that the crewman was busy with other duties. The third most frequent response dealt with the intelligibility of the transmission. Intelligibility has some component of noise which relates to the lack of understanding when the communication was loud enough. (Figure 24)

The protective Combat Vehicle Crewman (CVC) helmet was intended to provide three function. Those functions were to protect the head from blows; to provide a mounting for the communications earphones and microphones; and to provide noise attenuation. Throughout the test many of the CVC's were observed to be carelessly handled, dirty, and in less than optimum condition. The results of sampling at the end of Phase I and Phase III are shown in Figure 25. The general trend of the answers showed

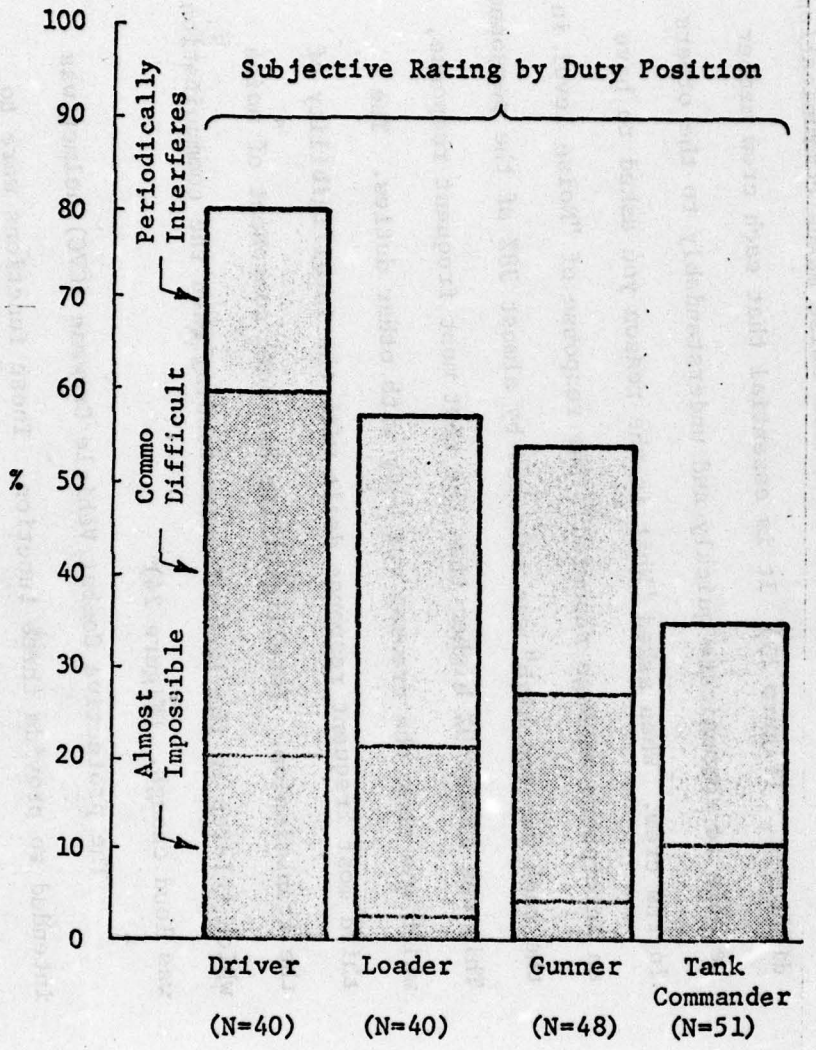

FIGURE 23. Noise Ratings by Duty Position

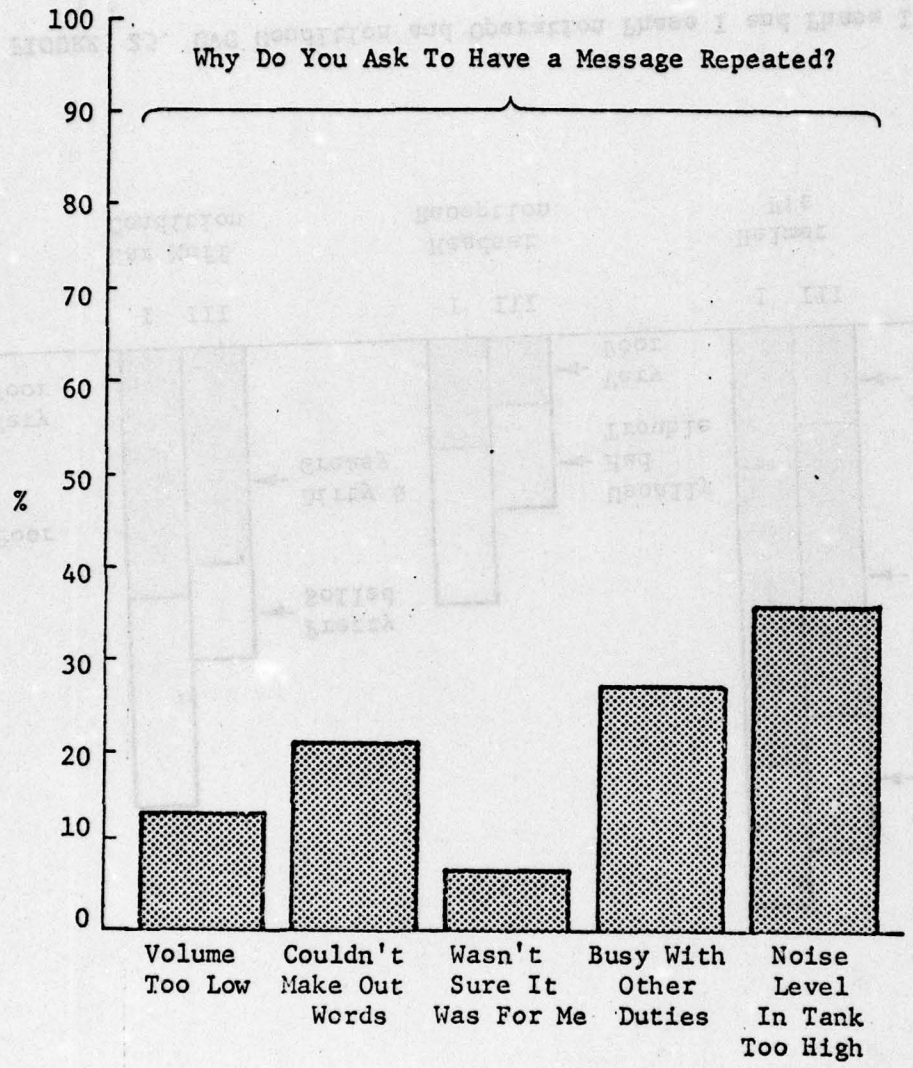

FIGURE 24. Reasons for Message Repeat Requests

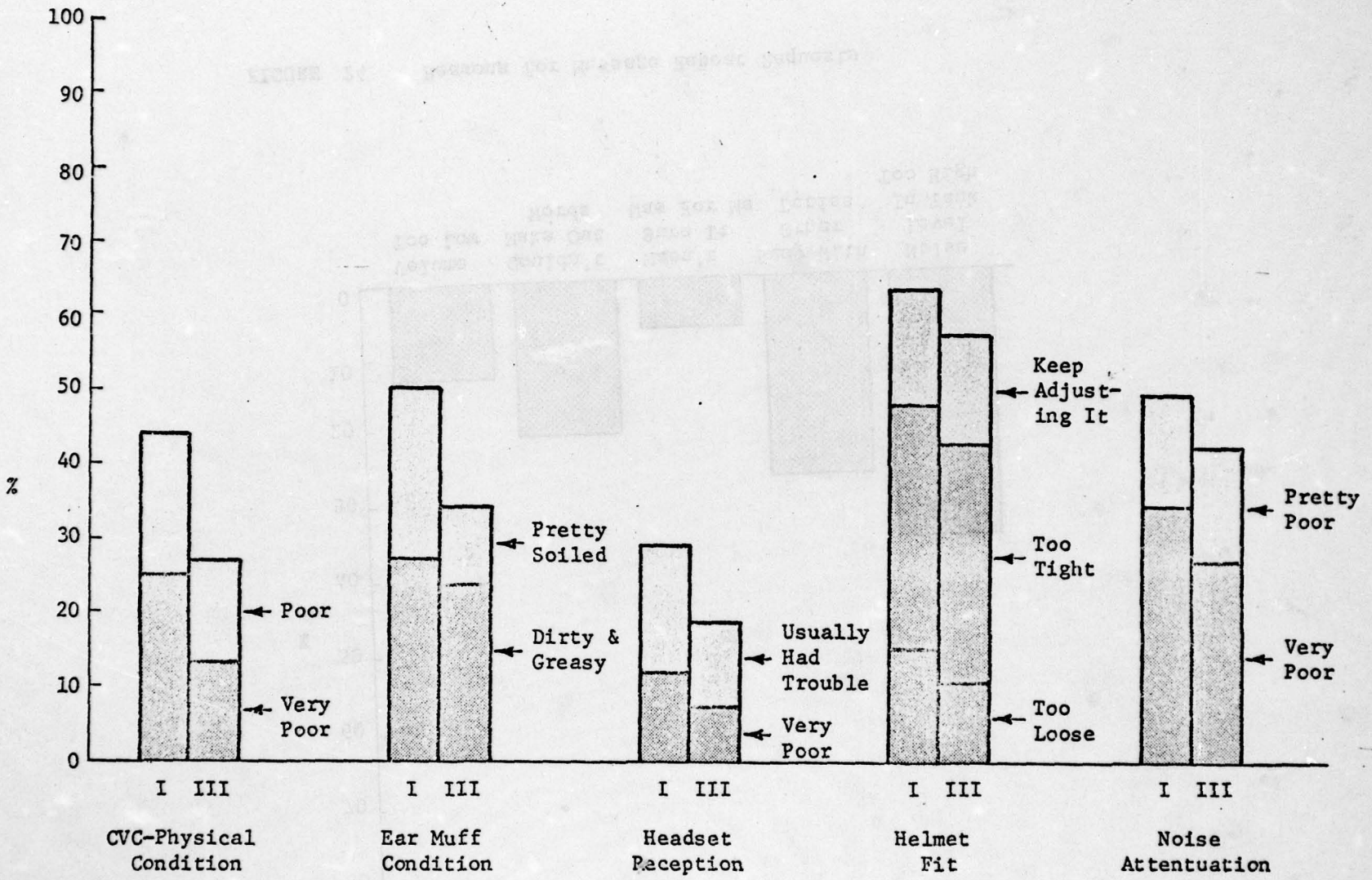

FIGURE 25. CVC Condition and Operation Phase I and Phase III

improvement from Phase I to Phase III. The response rate at the end of Phase III was still high for certain items. The physical condition, its fit and the noise attenuation, all rate negatively high for the primary means of intra-tank communication.

Warning and Advisory Lights:

There is a significant lack of consistency in the use of color coding for warning and advisory lights at all crew stations. The color red is used to indicate normal operation and also abnormal, inoperative, or hazardous (not normal) conditions.

Guidance found in the U.S. Army HEL Standard S-2-64A, Human Factors Engineering Design Standard for Vehicle Fighting Compartments, Displays, Color Coding states, "Red. Red should alert an operator to conditions that make the system inoperative, e.g., error, no-go, failure, malfunction, danger." Military Standard 1472 A, Human Engineering Design Criteria for Military Systems, Equipment and Facilities, states that red shall be used to alert an operator that the system or any portion of the system is inoperative, and that a successful mission is not possible until appropriate corrective or override action is taken. Examples of indicators which should be coded RED are those which display such information as "no-go", "error", "failure", "malfunction", etc.

3.5.1.2. Design for Safety

1) Driver's Station (Driver's Hatch)

While driving the tank with his head extending out of the hatch, there were several instances of the driver being struck by the turret ballistic shield as it rotated. On one occasion an accident occurred that caused injuries severe enough to require hospitalization for the victim. Informal interviews with various drivers also revealed numerous unreported incidents where bolt heads on the shield had snagged the drivers clothing and partially lifted him out of his compartment.

A study was made of this hazardous condition (Appendix E). This study revealed a reasonable means of significantly reducing the probability of the occurrence of this type accident/incident. The study showed that a movable roll bar type device effectively imposed a physical restraint on the height of the driver's head in the hatch, while still providing him with an adequate field of view.

2) Loader's Station

Loader Restraint

There have been instances of loaders who were not careful enough in keeping all of their body inside the turret perimeter as the turret begins to traverse. This resulted in one accident and many incidents, mostly unreported. The accident occurred when a loader was using an ammunition rack as a footrest, and the turret was traversed without him moving his foot. The turret

movement trapped his foot and it was crushed between the hull and the ammunition rack. Several toes were broken and the large toe was partially severed from the foot.

The loader is normally the least experienced member of the crew and therefore more likely than other crewmembers to forget safety training and/or miss the implication of an intercom message that turret power is going to be turned on. A removable safety screen which would cover the turret wall opening would prevent injuries.

Turret Drive Ring

The left side of the loaders station has an exposed portion of the turret drive ring which poses a significant hazard to the loader. There is a good likelihood that his arm, hand or clothing could become entangled in these gear teeth, resulting in severe injury if the turret was traversed. The configuration of the loader's station is such that some sort of an extension of the turret flooring or a mesh screen could be made to guard this hazard area.

3) Gunner's Station

Fire Extinguisher

A portable carbon dioxide fire extinguisher was provided for use in the event of a fire in the turret. This extinguisher was stowed behind the gunner on the rear of the turret power pack.

Observations and interviews showed that this stowage position severely limited the access to the extinguisher with no ammunition aboard. Due to the internal arrangement of the positions, access

to this extinguisher is considered totally impractical with a full load of ammunition aboard.

The location of this emergency device must be changed.

Gunner's Right Leg Position

The physical configuration of the gunner's workspace is such that the normal position of his right leg puts him in contact with the hull. In tropical and moderate temperatures, this has no safety implications. Weather significantly below freezing will cold soak the tank and create a safety hazard.

Experience has shown compression of clothing not designed for such use will develop a significant thermal leak. Continuous pressure of the gunner's leg against the turret wall in cold weather will result in frostbite at this pressure point.

4) Tank Commander's Station

Tank Commander's Footing

During the course of open terrain operation, several tank commanders lost their footing while standing on portions of the T.C. seat assembly. The Tank Commander normally operated a moving tank, except when under air attack, with the hatch open and at chest or shoulder height defilade. This gave an adequate field of view for guiding the tank, and afforded the maximum chance for target detection.

To achieve the desired height of defilade, it is necessary for all but the taller Tank Commanders to stand on the auxiliary platform or some of the seats ancillary structure, such as the height adjustment handle, or seat frame cross brace. The structures other than the auxiliary platform were not designed for standing

on for extended periods of time. The structures are strong enough for the task, but do not by their own design have the areas or safety features to retain a weighted foot when a sudden unloading/loading of the weight occurs. A sudden weight unload/load situation occurs when the tank encountered significant unseen dips or uneveness in the terrain.

There were two occassions when T.C.'s were thrown from their footing and both fell against the hatch coaming and then into the turret. Neither was standing on the auxiliary platform which is spring-loaded to the vertical position. One T.C. received bruised ribs and the other bruises on both arms and lacerations on one arm. Both were evacuated to the hospital for examination. A study of the T.C. seat assembly was made Appendix C) which discusses the seat assembly from another viewpoint.

5) All Stations

Sharp Edges and Corners

Crew members are continually beset by minor cuts and punctures while working in the crew stations. One fell through his hatch and cut his hand on the top of the ammunition rack while trying to break his fall. Edges and corners have not been blunted or rounded. Rounding of corners and blunting of edges will not affect the utility or or structural integrity of the material.

3.5.1.3. Design for Maintainability

In Tank Company Commander interviews one CO indicated that the problem with the M60A2 system, in terms of maintainability, is that the tank is too delicate. Procedures for quick-fixing an A1 in battle wouldn't work with the A2. Another CO observed, in a similar view, that the A2 required more maintenance than the A1 simply because it is more complex. The primary difference is in the turret systems, specifically the electrical system.

Maintenance supervisors who were interviewed also agreed that the maintenance workload on the A1 is less than that for the A2. While the tanks are automotively the same, the complexity of the turret and the sophistication of turret subsystems makes it extremely difficult to locate failures, replace parts, and repair single components. For the supervisors the greatest problem is with the stabilization mode with the laser system running a close second. Part of the problem for the stabilization system is that troubleshooting procedures are incomplete.

In a Phase II questionnaire 58 maintenance technicians were asked if the M60A2 tank was put together so that required maintenance and repair could be performed easily. Two- thirds (67%) of these personnel responded in the negative.

3.5.2. Conclusions - Problem for Human Engineering Design

- Crew stations were generally inadequate in terms of
  - Workspace
  - Seat Comfort
  - Seat adjustment
  - Ride quality

- The gunner's and driver's stations were inadequate in terms of ease of access/egress.
- Handholds and footholds for standup operations were inadequate in the TC and gunner stations
- The TC communication control accessibility was judged to be inadequate
- Safety hazards were noted in
  - the driver's head position out of the hatch
  - the exposed turret drive ring in the loader's station
  - inaccessibility of the gunner's fire extinguisher
  - the stand up position stability of the TC
  - sharp edges and corners in all stations

RESULTS OF ANALYSIS OF RESPONSES ON THE COMMUNICATIONS QUESTIONNAIRE ADMINISTERED AT THE END OF PHASE I

General

The questionnaire was completed by 152 crewmen from three tank companies and the HQ company. The distribution of respondents by company and duty position was as follows:

	Company				
Position	A	B	C	HQ	TOTAL
Driver	15	18	12	3	48
Loader	7	12	7	1	27
Gunner	8	15	8	1	32
Tank Commander	14	15	14	2	45
TOTAL	44	60	41	7	152

Specific Problems - Issues

Based on the review and analysis of responses, the following problems were identified:

- Almost one in three crewmembers (32%) rated the operation of tank radio equipment as poor or very poor.
- 27% rated intercom equipment as poor or very poor.
- The radio jack box is poorly located. A good majority (88%) of the crewmen reported having to move to see it, and 69% have to move to reach it. Visibility of the box is therefore somewhat worse than it's accessibility. In a tradeoff of location for visibility vs. accessibility, priority should be given to the visibility insofar as the crew will need to check control settings more frequently than they

will change settings.

- Almost 2 of 3 crewmen (62%) don't know why they position their intercom selector switch. This reflects definite deficiencies in training and in the availability of or knowledge of available standard operating procedures.
- While the loader has the responsibility of retuning a radio frequency while in the field, 55% of the crewmen sampled stated that it was the responsibility of the TC. This confusion of roles and responsibilities again points up deficiencies in training and standard operating procedures.
- 41% of the crewmen report that it is difficult to retune a radio frequency, probably due to the TC seat assembly design.
- Over half of the crewmen (54%) don't know if their unit had voice communications SOP or regulations. Again this demonstrates the need for improved training and crew briefing. When asked if a standard voice communications procedure was used in their tasks, one in five crewmembers said no, and one in three said sometimes.
- If a standard procedure for voice communication was reported, 32% of the respondents still did not know where it came from, and 30% thought it resulted from local custom.
- Only 18% reported that a standard procedure is used for alerting the TC that a duty position is ready.
- One in three crewmen don't know if tank checklists are available for standard modes of operation. 39% think they are available and 28% think they are not. This reflects deficiencies in crew briefing and training, and checklist dissemination.

- Two of three crewmen feel that checklists would be helpful.
- About half of the respondents rated the physical condition of CVC helmets, communications set, and ear muffs as poor. 60% of the crewmen reported problems with helmet fit. About 1 in 5 crewmen had problems with headset reception at the conclusion of Phase III (see Figure 25).
- Half of the crewmembers report that ear muffs do not adequately attenuate vehicle noise. (see Figure 25).
- A good deal of confusion exists in responses pertaining to which crewman checks the external intercom station. Again, this points up the need for SOP and training.
- Confusion also was reported when crewmen were asked whether the TC has a copy of the Signal Operating Instructions (SOI). While the crew should not know the contents of the SOI, they should know that it is required and is in the TC's possession. Again, a problem for training and crew briefing.
- While the need for improved communication procedures was evident based on the pattern of responses throughout the questionnaire, only 7% of the crew recommended improving the procedures when they were specifically asked if it is necessary.

4.0 RECOMMENDATIONS

The following recommendations for change were formulated to eliminate or alleviate the effects of problems identified in the conduct of the human factors evaluation of the M60A2 tank system. The recommendations are presented in the following areas:

- Personnel selection
- Training
- Operational and maintenance procedures
- Manuals and publications
- Equipment design (safety only)
- Communications

4.1 Personnel Selection

- Review the required skills and knowledges for the loader position.
- Emphasize training, specifically on-the-job training, over personnel selection.

4.2 Training

1. Course Content - Comprehensiveness or Scope

   - Additional emphasis on operator maintenance, specifically turret maintenance, should be placed on TC training at the Cadre School.
   - Crew training on the use and operation of the night passive devices allowed some crews to use the system more efficiently

than others during platoon ATT training and throughout the test. Where feasible, targets should be set out at known distances and crewmembers required to detect and acquire during night training.

- Both operational and maintenance crewmen should receive additional training with the emphasis being on "hands-on" training. Many of the responses to the questionnaires reflect this attitude.
- Maintenance training should place emphasis on those new systems which were reported as creating the heaviest workload. These include the stabilization, turret electrical, and the missile guidance and control systems.
- Specialized training should be given drivers in the use of the IR driving system. There is reluctance to use the system, which may be the result of the lack of training.

2. Course Content - Coverage

- In training TC's and Gunners, additional coverage must be given in the following subject areas:
  - armament, controls, and equipment
  - conduct of fire
  - auxiliary fire control instruments and range cards
  - prepare to fire procedures
  - conduct of fire trainer
  - operator maintenance
  - laser range finder operational procedures
  - boresighting

- crew drill
- stabilized gunnery
- night firing

- In training loaders, additional emphasis and coverage must be given to:
  - basic tank gunnery
  - reduction of weapon malfunctions
  - preparation of ammunition for firing
  - identification, stowage, and maintenance of ammunition
  - crew maintenance
  - crew drill
  - M73-85 mechanical training
  - grenade launcher
  - system self test - verification
  - recoil mechanical check
  - misfire procedures
  - align LRF
  - emergency fire procedures
- In training drivers, additional coverage must be given to:
  - techniques of fire adjust
  - range determination
  - operation of firing mechanisms
  - clearing misfires
  - tank loading
  - characteristics of ammo

- before operations check (hull)
- start-stop procedures
- response to ground guide signals
- level and varied terrain driving
- perform as ground guide
- after operations check
- use of operations manual and lubrication order

- For maintenance training, additional coverage is required on use of manuals and test sets, and on the CBSS system.

3. Course Content - Clarity

- No unique problems were identified. Problems with course content clarity are closely related to problems of instructor skills and knowledges and training aids and materiels, and are treated in those sections.

4. Course Content - Consistency

- One of the major problem areas identified for M60A2 tank crew training was the absence of consistency or standardization of the course content as presented to different trainees. This problem of non-standardization applies equally to instructor skills, training aids, and measures, as well as to course content. It is strongly recommended that the training to be administered to candidate M60A2 tank crews in the future be formalized and standardized such that the information presented to different trainees is comparable.

- When local (unit) training is scheduled, personnel who are to attend should be excused from other military duties in order to avoid interruptions of the class and to ensure a continuity of training for each crewman.

5. Course Content - Compatibility

- Criticism of M60A2 training often voiced by trainees was that the course materiel was presented without any consideration to their individual requirements and capabilities. Thus, they would spend what to them was excessive time on subjects they already understood, leaving less time for areas where they needed more intensive instruction. This problem must be resolved in conjunction with the resolution of the course content consistency problem cited under Item 4 above. The training course established for M60A2 tank crewmen must be better formalized, structured to a greater degree, and standardized. It must at the same time be flexible enough to effectively train crewmen having a wide range of natural ability and motivation. Two approaches seem feasible to meet this flexibility requirement: programmed instruction, and availability of trainers and training aids in sufficient number to enable crewmen to practice specific operations on their own. The programmed instruction approach has the advantages of being self-paced and being directed to individual training. Consideration should be given to the use of programmed instruction techniques to supplement

classroom instruction. The availability of trainers and training aids appears to be the more effective approach to enabling trainees to devote more time to areas where they or their instructors feel they require additional practice. Such devices can range in complexity from simple handouts expanding on classroom material, to sophisticated tank trainer systems. These will be discussed in greater detail under training aids and materials.

6. Instructor Skills and Knowledges

- It is recommended that either skilled instructors be used for training, or that battalion personnel selected to instruct others be administered a short course in how to effectively instruct. They should also be provided with lesson plans, handouts for the class, and training aids (visual aids, mockups, etc.).

7. Training Aids, Materials, and Media

- A variety of crew trainers (mockups) should be developed. Each crewmember should be given the opportunity to receive training in a mockup of his own crew station. This releases operable hardware (tanks) for other uses and provides crew and equipment safety. Crew safety factors could be emphasized without endangering personnel. Also, malfunctioning trainers would be easier to repair than actual tank systems. These mockups could also be constructed for use in maintenance training. In developing any trainers, consideration must be given to at least two factors: (1) fidelity of the trainer and, (2) cost. Obviously, the trainer with a higher fidelity or representation of the system will have a higher initial cost but could save considerable money

after usage. It precludes tying up operational hardware and provides crew and equipment safety.

- For training aids used in classroom instruction, sufficient aids should be available to ensure a ratio of no more than four students per aid, and preferably two students per aid.
- As with course content, the training aids and materials, including lesson plans, handouts, and mockups need to be standardized so that the effectiveness of the aids and materiels can be established, and also to ensure that all students receive the same training.

8. Training Measures and Criteria

- Standardization of measures and criteria is the most critical requirement. Measures should be derived based on standard tests (paper and pencil, oral, demonstration). Tests should be constructed such that the evaluation can identify weak areas for remedial training.
- Criteria should be expanded beyond a simple pass/fail to enable and facilitate identification of weak areas when additional training is required.
- The pre-gunnery examination should be restructured such that each trainee proceeds through the course on two different

occasions. In the first session, he is tested and scored. The scoring is done, however, only to identify weak areas. Remedial training is provided immediately, prior to moving to the next station. After completion of this session, the trainee proceeds through the second session where formal testing is performed. Scoring should be structured such that at the conclusion of the formal test, the trainee passes the course, requires additional remedial training, or fails. In this situation, remedial training will involve reprocessing through the gunnery course with special emphasis on weak areas identified in the test. Action to be taken in the event of a fail will need to be determined on a policy basis.

4.3 Procedures

Following is a list of the recommendations to be made that relate to problems aggravated by inadequate procedures:

- A standard communications procedure for both message content and frequency of reporting should be established and enforced. This would ensure clarity (understandability) of the message and reduce traffic to the absolute minimum required.
- During ATT training, it was noted that unit leaders did not assign targets to any particular element under their command when multiple targets were acquired. Such a situation could lead to over-kill on some targets with the remainder not receiving fire or detection. This was probably a training peculiar condition; however, this procedure should be practiced whenever

possible to produce ingrained behavior.

- Procedures should be established to ensure that crew daily maintenance inspection and servicing is performed to preclude equipment damage.
- Moisture-proof checklists and/or decals should be fabricated for use at each duty station. These should be constructed for those procedures which require the use of job aids, whether routine or non-routine. These checklists should reflect the sequencing of steps as outlined in the various appropriate manuals.
- To gain access to the conventional rounds located in the lower right ready racks, the procedure for conduct-of-fire should require the loader to use the forward-most missile around the gunner's compartment as the first missile round to be fired. Conventional rounds cannot be retrieved without the missile and pod being removed.
- There is a general requirement for improvement and enhancement of standard operating procedures. Tank commanders and company commanders reported in interviews that the following items need to be formalized as SOP'S:
  - stabilization system operations - when to use it, etc.
  - require that the engine be running when turret power is required
  - standardize the frequency of CBSS checks
  - use a dipstick to check turret fluid levels rather than a visual estimation of fluid quantity
  - target engagement techniques

- carry position
- simplified and standardized prepare-to-fire checks
- standard uniform
- minimum acceptable crew size for training (should be three rather than two crewmen)
- restrictions on wearing binoculars around the neck
- provision for using a hand microphone or loudspeaker
- battle sights
- pre-combat checks
- frequency of system exercise
- missile subsystems checks

4.4 Manuals

The manuals used to support the M60A2 were found by human factors standards to be inadequate. This was supported by responses on the various questionnaires administered to the tank crews and maintenance personnel. In order for manuals to receive more widespread use and become more effective, the following recommendations were formulated.

- Sufficient manuals should be available to individual crewmen during training.
- The manuals need to be revised with regard to arrangement. For example, the -10 manual (TM 9-2350-232-10, Operator's Manual) would be easire to use if all aspects of a duty station were listed in one subsection. As it now stands, information for the driver is found in pages 2-2 through 2-15, 2-55 through 2-65, and 2-147 through 2-151 rather than all being under one section concerned only with driver requirements. The same is true for all duty stations so that a technical manual user must skip from section to section to find the information he needs. A saving on time

and reduced confusion would result from rearrangement.

- In keeping with the concept of rearrangement, unbreakable, moisture-proof index tabs should be employed to enable the user to immediately find the section in which he is interested.
- A type of binding which allows the document to lie flat (remain open) is required. It is difficult to use a manual that keeps flipping pages when one is attempting to follow instructions.
- In content, the instructions must be clear as must be the illustrations. Instructions and illustrations which are not clear contribute highly to non-use of a manual.
- When operations must follow a particular sequence, this should be noted and specified in the manual. Frequently, shortcuts will be attempted which lead to damage or non-optimal operation or repair of the system.
- Consideration should be given to breaking up a large manual into several smaller documents. The organizational manual (-20) has 700 pages of materiel for the turret mechanic. This material could easily be segmented at least by user and, for maintenance users, by system or by maintenance function (troubleshooting, installation, qualification test, etc.).
- The primary defect with M60A2 manuals (and with most operational and maintenance manuals) is that they place too much emphasis on comprehensiveness and coverage, and not enough on user requirements and constraints. Manuals and checklists are generated with the intent of including, under one cover, any and all information

which a user might require, without giving due consideration to the time, effort, workload, and skill requirements on the part of the user to find the information that he needs to use it effectively to perform his designated activity. Consideration should be given to other approaches to present information, such as graphic flow diagrams for troubleshooting or installation, programmed checklists for computer driver display, and generally a wider use of symbology and graphics as opposed to pages of text.

4.5 Design

As was specified in the Introduction to this report, design problems were only to be noted and no specific recommendations made except where crew safety was involved. Several design problems were reported during the conduct of the test which were safety oriented, these being the TC foothold/handhold problem (See Appendix E, Driver Safety Study) and loader safety. Recommendations made in this section will address only these problems. The reader is referred to Subsection 3.5 of Section 3.0 (Results and Discussion) of this report for the enumeration of the other design problems.

- During the course of the ICTT, several TC's were injured when their feet became dislodged from their footholds when the tank struck a ditch or depression. A study was performed to determine the adequacy of the TC station; particularly the seat assembly (including the auxilliary platform) since this is the primary footrest. The recommendations made included investigation of a seat assembly similar to that used in the M60A1 tank and improving the footholds/handholds available in the M60A2. Some specific changes which can be considered would be allowing the main platform to rise higher on its rails

than it currently does. This platform provides a larger surface area than the seatframe cross brace does and would not allow the TC's feet to slip off as readily when a ditch or depression is encountered in cross country travel.

The M60A1 type seat would also allow the TC to sit during cross country travel, thereby lowering his center-of-gravity as well as providing comfort. He would again be more resistant to being dislodged and injured.

- One of the loaders received injury to his foot when he allowed his foot to protrude outside the basket. When the turret was traversed, his foot was crushed between the turret and an ammunition rack which provided a "convenient" footrest. The opening in the turret is necessary to allow access to ammunition storage racks; however, an easily removable screen guard would provide protection and still provide access when necessary.
- Driver safety problems were reported when two, on separate occasions, received varying injuries from being trapped between the gun tube mount and their compartment hatch openings. One of these received severe facial injuries (i.e., crushed cheek-bones and severe lacerations requiring approximately 16 sutures) when he was "scissored" in this manner. Other drivers reported incidents where exposed bolt heads on the gun tube mount weather shield snagged the driver's clothing and lifted him partially out of the compartment. A positive restraint of a roll-bar configuration was recommended to keep the driver below the gun tube mount's lowest point. A mock-up was fabricated and tested

and proved to be feasible. It is recommended that such a device be employed on the M60A2.

- There is a potential for the gunner, due to his seating/workspace layout, to be exposed to frost-bite when operating under cold weather conditions. His right leg is forced to rest against the turret wall, compressing his clothing. This could result in a thermal leak where his leg would become cold - soaked through the turret wall - and injure him. Additional insulation on the leg would prevent this.
- The five pound portable fire extinguisher should be relocated to be more readily accessible in the turret. With a full ammunition load, this unit is hidden and could not be easily used in an emergency.
- Sharp edges and corners should be removed to eliminate cutting and/or puncturing of personnel. Where materiel thickness does not permit sufficient smoothing, the edge/corner should be covered with a protective materiel (e.g., teflon tape, etc.) to preclude injury to crewmen.
- The turret drive gear ring is exposed just to the loader's left side. It is conceivable that the loader could become enmeshed in this ring as the turret is being driven and sustain injury as a result. A simple screen guard covering this ring would preclude such an injury from occurring.

APPENDIX A

Preliminary Task Analysis

M60A2 Tank Crew Operations For:

- Pre/Post operational check
- Carry mode operation
- Conduct of fire-conventional-all modes
- Conduct of fire-missile engagement
- Conduct of fire-COAX engagement
- Conduct of fire- .50 caliber engagement

TASK ANALYSIS - CREW PRE/POST - OPERATION CHECKS

TASK NO.	TIME	CUMULATIVE TIME	INPUT TYPE	TANK COMMANDER	LOADER	GUNNER	REMARKS
			check-list	Ensure following switch/indicators set correctly: . hydraulic system switch - normal . cupola power switch - off . XM51 filter knob - off . laser mode selector - test . search light switch - off . grenade selector - off . computer power switch - off . cant switch - off . periscope power - off . periscope wiper switch - off . wind scale indicator - zero	. vent blower switch - off . turret/gun drive switch - locked	. range input switch - manual . wind input switch - manual . computer power switch - off . cant switch - off . normal/boresight switch - normal . periscope power switch - off . wind scale indicator - zero . telescope reticle knob - ccw . stab/hydraulic switch - normal . turret power switch - off . armament selector - conu . XM50 filter knob - off . laser mode selector - test	

TASK ANALYSIS - PREPARE TURRET FOR CARRY MODE OPERATION

TASK NO.	TIME	CUMULATIVE TIME	INPUT TYPE	TANK COMMANDER	LOADER	GUNNER	REMARKS
				complete all pre/ post operation checks supervise loading of grenade launcher announce start engine After crew reports ready: . cupola power switch - on . computer power switch - on . periscope power switch - on Open periscope shield by actuating handle . position periscope flip lever For 8 power (day) or 10 powered (night) operation Adjust periscope reticle brightness . laser mode selector - on Load cupola gun	complete all pre/ post operation checks announce ready load coax . gun breech switch - close . re-check turret/ gun drive switch - locked . ejector lever - non-eject	complete all pre/ post operation checks announce ready load grenade launcher . range switch computer panel switch - automatic . computer power switch - on . periscope power switch - on . turret power switch - on . laser mode select - auto . press reset button on laser ranging control panel . check for computer unit in control . open periscope shield by actuating lever . open telescope shield by actuating lever . position periscope flip levers for day (8X) or night	Driver starts engine; turns CBSS on by setting gun scavenge switch on - driver announces ready after closing and locking hatch cover

TASK ANALYSIS - PREPARE TURRET FOR CARRY MODE OPERATION
(Continued)

TASK NO.	TIME	CUMULATIVE TIME	INPUT TYPE	TANK COMMANDER	LOADER	GUNNER	REMARKS
						(10X) operation . adjust periscope reticle brightness . adjust telescope reticle brightness	
				Stab switch - on Using AZ and EL knobs on commander's panel - null cupola	Turret/gun drive switch - normal Position gun for loading turret/gun drive switch - locked	On gunner's control panel using stabilization null AZ and EL knobs - null turret	
			SYSTEM READY FOR DRIVING OPERATION PREPARATORY FOR ENGAGEMENTS				

TASK ANALYSIS* - CONDUCT OF FIRE - CONVENTIONAL AMMUNITION - ALL CONDITIONS

TASK NO.	TIME	CUMULATIVE TIME	INPUT TYPE	TANK COMMANDER	LOADER	GUNNER	REMARKS
			Visual	Acquires target (orders driver to stop if in motion and wishes static position)	·Note - gun/turret drive is in <u>locked</u> position during pre-operation procedures	·Note - armament selector pre-set to <u>conv.</u> during pre-operational procedures	Driver brings tank to slow smooth stop if so ordered
			Verbal	<u>Gunner</u> - <u>Heat Tank</u> (target type announcement at this time favored by some crews to alert gunner early and save time for identification later)	Breech switch - <u>open</u> until breech drive motor stops	Depress ammunition select button on computer panel - <u>heat</u>	System set for operating conduct of fire by setting vehicle for carry mode
				Traverse cupola to target using Cadillac handles	Selects round and places on loading tray	If static - turn cant switch - <u>on</u> - see remarks	
				Upon hearing <u>Up</u>, announces <u>designate</u> (alerts crew turret about to traverse) sets target designate switch to <u>command</u> (turret slews to Los with TC's periscope setting in azimuth; 4.5 seconds maximum time)	Grasps barrier bag with left hand and peels from round by pushing with right hand at base to load	Check <u>range</u> button on <u>laser ranging control panel</u> for flashing light	
					Discards barrier bag	Upon traverse to target area, searches for target through the XM50 periscope	
					Breech switch - <u>close</u> until breech drive motor stops		
					Check alignment marks to insure breech closed		
					Insure recoil path clear		
					Set turret/gun drive switch - <u>normal</u>		

*Assumes: <u>All</u> pre-operational checks completed - all conditions refers to moving or stationary tank/moving or stationary target; vehicle operating in <u>carry</u> mode

TASK ANALYSIS* - CONDUCT OF FIRE - CONVENTIONAL AMMUNITION - ALL CONDITIONS
(Continued)

TASK NO.	TIME	CUMULATIVE TIME	INPUT TYPE	TANK COMMANDER	LOADER	GUNNER	REMARKS
				Upon hearing identified, releases control of turret by release of target designate switch Checks later panel indicators malfunction and select lights and range readout; if range return satisfactory and fed to computer, moves to position to observe and announces fire Announces cease fire at end of engagement	Set main gun fire/safe switch - Fire Check for ready light (above fire/safe switch) - illuminated Turn vent blower switch - on Announce up	Acquires target in periscope and announces Identified Upon release of turret, lays on target by setting periscope reticle on target. Presses range button (left hand push button on cadillac handle) and tracks target for 2 seconds Makes final precise lay on target and announces on the way Waits one second and presses trigger button on cadillac handles	

NOTE: If multiple rounds required on selected target:

- commander repeats all of his tasks - issues any correction commands to insure hit on target
- loader places turret/gun drive in locked - then repeats all his tasks
- gunner repeats his tasks starting with step for checking laser control panel for flashing half of range button

TASK ANALYSIS - CONDUCT OF FIRE - MISSILE ENGAGEMENTS

TASK NO.	TIME	CUMULATIVE TIME	INPUT TYPE	TANK COMMANDER	LOADER	GUNNER	REMARKS
				Acquires target; orders driver stop to half vehicle Issues commands gunner-missile-(target type) Lays cupola gun for direction Announce designate . target designate switch - command	Holds breech drive switch - open until motor stops Places eject lever - (eject position) down Selects missile and lays on loading tray with loading index up and missile key engaged in keyway on tray Slides missile into breech Holds breech drive switch - close until motor stops Checks breech/launcher marks aligned Checks recoil path clear Turret/gun drive switch - normal Main gun switch-fire Checks for ready light -on	Armament selector switch - missile Check transmitter door indicator - white Search for target through telescope Upon acquiring target, announce identified	Driver brings tank to slow, smooth stop

TASK NO.	TIME	CUMULATIVE TIME	INPUT TYPE	TANK COMMANDER	LOADER	GUNNER	REMARKS
				Releases control of turret by releasing target designate switch when gunner announces identified Moves to position to observe and announces fire On completion of engagement announces cease fire	Vent blower - on Announces up Turns vent blower off Sets turret/gun drive switch - locked Sets breech drive switch - open until drive motor stops Removes aft cap from ejected position and discards Set breech drive switch - close until motor stops	Checks terrain clearance through the telescope Announces on the way Presses trigger one second later Maintains aiming cross on the target during launch and missile flight Places armament selector in conventional Places hydraulic/ stab switch in normal Positions gun for loading and travel	If turret drift evident or manual mode desired, gunner sets hydraulic/stab switch off If manual mode used as described above

NOTE: If more than one round needed for target destruction:

1. TC repeats all his tasks
2. Loader repeats all his tasks
3. Gunner repeats tasks beginning with identification of target through his telescope

TASK ANALYSIS - COAX ENGAGEMENT - STATIC AND/OR TANK MOVING

TASK NO.	TIME	CUMULATIVE TIME	INPUT TYPE	TANK COMMANDER	LOADER	GUNNER	REMARKS
				Issued directions to engage in stabilized mode Issues elements of fire command Gunner-Coax-Troops Announces target designate; sets target designate switch to - command Releases control of target by releasing target designate switch. Estimates and announces range to target Moves to position to observe and announces fire Upon destruction of target, announces cease-fire	Places turret/gun drive switch - normal Places coax manual safety - fire Places turret vent blower - on Announces - up Places coax manual safety - safe Places turret/gun drive switch - is locked Turns turret vent switch - off	Places armament selector -coax Observes through telescope Upon acquisition of target announces identified Makes final lay on target using appropriate range line in telescope Announces on the way Presses trigger to fire 20-25 round bursts Traverses area with fire Places armament selector switch to Conventional Positions gun for loading and travel	The driver maintains a steady course and speed driving toward the target if possible

TASK ANALYSIS - 50 CALIBER ENGAGEMENT - STATIC OR MOVING MODE

TASK NO.	TIME	CUMULATIVE TIME	INPUT TYPE	TANK COMMANDER	LOADER	GUNNER	REMARKS
				Alert crew by announcing caliber - fifty Place mechanical safety in Fire Ensure that the gun select switch is in Cup Lay gun on target using cadillac handles and appropriate range line in the ballistic reticle on the TC's (XM-51) periscope Fire by pressing trigger on cadillac handles: . 10-20 round bursts against ground targets . continuous against aircraft Announces cease fire upon termination of engagement Set mechanical safety to safe			

APPENDIX B

GUNNERY QUESTIONNAIRE

GUNNERY QUESTIONNAIRE (B1)

Tank Commander

Name: _____ SSN: _____

Date: _____ Company: _____ Platoon: _____

1. The arrangement of switches, displays, indicator lamps, circuit breakers, etc. at your tank duty position is:

A. Unacceptable

B. Inadequate - to reach and/or see

C. Borderline - can reach and/or see with some difficulty

D. Adequate - some minor problems to reach and see them

E. Very Good - no problems to reach and see them

2. The room (work space) available at your tank duty position is:

A. Unacceptable - too cramped and/or dangerous

B. Inadequate - cramped and/or sometimes dangerous

C. Borderline - can manage my duties with some difficulty

D. Adequate - some minor work space problems

E. Very Good - no work space problems

3. The things you have to do to prepare for a conventional ammunition engagement:

A. Too many things to do

B. Very many - a large number of things to be done in a very short time and/or done very accurately

C. Borderline - can do them with some difficulty

D. Adequate - only minor problems

E. Easily done

4. The steps you have to follow for a conventional ammo engagement are:

A. Too difficult to follow

B. Difficult to follow - usually make some mistakes

C. Borderline - some steps need to be improved

D. Adequate - only minor problems doing the steps

E. Very Good - the steps assist you in a successful engagement

BI - TC

5. The things you have to do to prepare for a missile engagement:

A. Too many things to do

B. Very many - a large number of things to be done in a very short time and/or done very accurately

C. Borderline - can be done with some difficulty

D. Adequate - only minor problems

E. Easily done

6. The steps you have to follow for a missile engagement are:

A. Too difficult to follow

B. Difficult to follow - usually make some mistakes

C. Borderline - some steps need to be improved

D. Adequate - only minor problems doing the steps

E. Very Good - the steps assist you in a successful engagement

7. The job of nulling the cupola (killing its drift) is:

A. Very Difficult

B. Difficult

C. Borderline

D. Adequate - only minor problems

E. Very Easy

8. Once nulled (drift killed) the cupola nulling should be:

A. Left alone

B. Checked periodically, infrequently

C. Checked frequently

D. Checked when misalignment to target noticed

E. Checked almost continuously

9. When selecting a target, how much do you work with other tanks in the unit to spread the number of targets among the tanks?

A. Never - each tank selects a target independently of the other tanks

B. Occassionally - depending on the tactical situation

C. Usually

D. Whenever possible

E. Always

10. The procedures for finding and laying the cupola gun on the target (traverse cupola to target and designate) are:

A. Very difficult and time consuming

B. Difficult and somewhat slow

C. Borderline - some problems

D. Adequate - some minor problems

E. Easy

11. If a target is detected by one of the crew other than you, the procedure for alerting you of the target and its location with respect to the tank is:

A. non-existent - that crewman merely reports to me

B. Available but inadequate - the procedure must be improved

C. Borderline - the procedure should be improved

D. Available and adequate - some minor problems need improvement

E. Very Good - no problems

12. If the cupola gets off the designated target after the main gun is aligned with the cupola the T. C. should:

A. Correct main gun to target without adjusting cupola alignment

B. Adjust cupola position and traverse main gun

C. Complete the designation procedure again - all the steps

D. Direct the gunner which way to traverse the main gun to the target

E. Allow the gunner to correct main gun alignment if he has target identified

13. The location and arrangement of the target designate equipment is:

A. Very Poor

B. Inadequate - makes using it very difficult

C. Borderline - can be used with some difficulty

D. Adequate - some minor problems but can perform the operation

E. Very Good - the design and arrangement assists me in performing the operation

14. Are the steps for the Target Designate procedure as laid out in the manuals and SOP's adequate? Indicate by an X for each of the following.

	(a) Must Change	(b) Desire Change	(c) No change
A. Manuals	_____	_____	_____
B. SOP's	_____	_____	_____

15. When do you recommend use of the laser range finder?

A. Don't use it

B. Use it when time permits

C. Use it when target has clear outline

D. Use it when range estimation is difficult

E. Always use it when it's working

16. With a chance to change things in the Target Designate operation, show which things must be changed and where changes are desired. Indicate by an X for each of the following:

	(a) Must Change	(b) Desired Change	(c) No Change
A. Location of cupola traverse controls			
B. How the cupola traverse controls work			
C. Location of my periscope			
D. How good the periscope display is			
E. Location of Target Designate switch			
F. How acceptable is the type of Target Designate switch			
G. How the Target Designate switch operates			
H. Amount of room to operate (work space)			
I. Amount of clearance from things in the workspace			
J. Location of footholds			
K. Location of main platform			
L. How my main platform adjusts			
M. How the auxiliary platform works			
N. Number of steps to do a Target Designate			
O. Order of steps to do a Target Designate			
P. Difficulty of steps to do a Target Designate			
Q. Information displayed to me for Target Designate			
R. Ease of communication within my tank			
S. Ease of communication with other tanks			

17. The loading and operation of the cupola gun due to:

	(a)	(b)	(c)	(d)	(e)
A. Its weight is					
B. Length of the rounds is					
C. Location of the chamber is					
D. Way the gun is mounted is					
E. Ammo feed system is					
A. Reject g after stoppage is					

(a) Very Difficult (b) Difficult (c) Borderline (d) Adequate (e) Very Good

18. What do you do when the range to the target as estimated by you does not agree with the laser range readout?

A. Reject the laser range and use my estimate

B. Check the laser range if you have plenty of time

C. Always check the laser range

D. Always believe the laser range

E. Range again with the laser by the gunner or me

19. What do you do if you suspect a laser range finder malfunction?

A. Rely on visual range estimates using periscope reticle pattern

B. Assume control of the laser ranger and try ranging again

C. Request gunner to repeat ranging

D. Turn laser ranger Off for a moment then back On

E. Check curcuit breakers

20. How effective is the laser range finder?

A. More trouble than its worth

B. Useful but difficult and/or time consuming to operate

C. Borderline - has some problems

D. Useful in some situations, have to decide when to use it

E. Very Effective - must be working for best firing results

21. How do you like the layout and the way things are arranged for work at your tank duty position?

A. Very Poor - very difficult to perform my required jobs

B. Poor - have problems doing most jobs

C. Borderline - have problems with some jobs

D. Adequate - have problem with very few jobs

E. Very Good - no problems

22. How was the gunnery training given to you and your crew:

A. Not enough to get us ready for firing tables

B. Inadequate - with some major problems

C. Borderline - with some problems

D. Adequate - with some minor problems

E. Very Good

BI - TC

23. Arrange the following things in terms of their importance in the decision of which gun and ammunition to use. Place the things in your preferred order by placing (a) in the blank space of the thing you think is most important, put (b) by the second most important until all the things have a letter in the blank space behind them.

A. Type of target _____

B. Number of potential targets _____

C. Range to target _____

D. Degree of threat to own tank _____

E. Target location _____

F. Deployment of own tanks _____

G. Deployment of enemy forces _____

H. Disposition of ammunition (quantity) _____

24. With a chance to change things in the laser range finder system, show which things must be changed and where changes are desirable. Indicate by an X for each of the following:

	(a) Must Change	(b) Desire Change	(c) No Change
A. Sharing control between TC and Gunner	_____	_____	_____
B. Steps necessary to get control of laser due to sharing	_____	_____	_____
C. Rules for deciding when to take control of system	_____	_____	_____
D. Deciding which range is being displayed	_____	_____	_____
E. Where your laser readouts are located	_____	_____	_____
F. Types of switches and controls for system	_____	_____	_____
G. Where the laser controls are located	_____	_____	_____
H. How hard is it to decide the range is correct	_____	_____	_____
I. How difficult is the laser system to operate	_____	_____	_____
J. Are operating procedures standardized enough	_____	_____	_____
K. Are you confident enough in laser ranges	_____	_____	_____
L. How was training for laser range finding	_____	_____	_____
M. Is there enough time for laser practice	_____	_____	_____
N. Are there enough safety instructions for laser	_____	_____	_____

25. Show which things in gunnery training need to be changed. Show which ones must be changed, and in which ones change is desirable. Indicate by an X for each of the following.

	(a) Must Change	(b) Can Improve	(c) No Change Required
A. Quantity of training overall			
B. Quantity of dry fire practice			
C. Instruction on individual firing duty procedures			
D. Instruction on crew procedures			
E. Training aids and materials			
F. Training tests and examinations			
G. Retest procedures after failure of Pre-Gunnery Exam			

26. Show which of the things related to gunnery training that need to be changed. Which must be improved, and which can be improved. Indicate by an X for each of the following:

	(a) Must Change	(b) Can Improve	(c) No Change Required
A. Amount of time spent in actual range firing			
B. Amount of time spent in actual firing in simulated combat exercises			
C. Amount of time spent in instruction on tactics			
D. Amount of time on Tables 1-3			
E. Amount of time on Tables 4-5			
F. Amount of time on Tables 6-7			
G. Amount of time on Table 8			
H. Amount of time on refiring			

27. How does tank noise interfere with communications in the tank:

A. Makes communication almost impossible

B. Makes communication difficult

C. Periodically interferes with communication

D. Seldom interferes with communication

E. Does not interfere with communication

28. Is your seat:

A. Extremely uncomfortable

B. Moderately uncomfortable

C. Comfortable some of the time - uncomfortable at intervals

D. Comfortable most of the time

E. Always comfortable

BI - TC

29. Are seat adjustments:

A. Unacceptable - can't adjust it

B. Inadequate - not enough adjustment must be improved

C. Borderline - could be improved

D. Adequate - minor problems

E. Very Good

30. Do you have difficulty entering and leaving the tank by your hatch:

A. Always great difficulty

B. Always moderate difficulty

C. Borderline

D. Only when wearing heavy clothing or carrying a load

E. Never - always easy

31. How are your jobs for conduct of fire different when the tank is moving as opposed to standing still:

A. Much more difficult

B. Somewhat more difficult

C. Borderline

D. About the same

E. Easier

32. During firing of the main gun, is the internal environment (temperature, humidity, fumes, etc.) of the tank:

A. Almost unbearable

B. Bearable for short periods

C. Uncomfortable

D. No problem

33. Is the ride quality of the tank such that when it moves you are:

A. Usually very uncomfortable

B. Occasionally very uncomfortable

C. Borderline

D. Moderately Comfortable

E. Comfortable

BI - TC

34. Is the location of your radio controls such that it is:

A. Almost inaccessible - sometimes requires some one else to switch channels

B. Difficult to get at some controls - Detracts from other duties

C. Borderline

D. Adequate - with some problems but does not interfere with other duties

E. No problems

35. Is the operation of your platform (raising and lowering of the platform):

A. Extremely difficult and time consuming

B. Moderately difficult

C. Borderline

D. Adequate much of the time

E. Easy

36. Are handholds and footholds used during stand-up operation with the tank in motion:

A. Inadequate and/or unsafe

B. Marginal - some major problems

C. Borderline

D. Adequate - only minor problems

E. Excellent - no problems

34. Is the location of your radio controls such that it is:

A. Almost inaccessible - sometimes requires someone else to switch channels

B. Difficult to get at some controls - Detracts from other duties

C. Borderline

D. Adequate - with some problems but does not interfere with other duties

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35. Is the operation of your platform (raising and lowering of the platform):

A. Extremely difficult and time consuming

B. Moderately difficult

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D. Adequate much of the time

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36. Are handholds and footholds used during stand-up operation with the tank in motion:

A. Inadequate and/or unsafe

B. Marginal - some major problems

C. Borderline

D. Adequate - only minor problems

E. Excellent - no problems

37. Did you have any unscheduled down-time during tank gunnery?

A. Yes

B. No

38. If you answered Yes on Question 37, was this due to:

A. Range closed

B. Maintenance required

C. Shortage of personnel such as AI's, Safety Officer's, etc.

D. Waiting for firing tanks to clear down-range points

39. If your donw-time was due to maintenance, what system was the course?

    A. Hull

    B. Automotive

    C. Communications - radio/intercom

    D. Armament System (specify)

        1. Main Gun

        2. Coax

        3. 50 Caliber

    E. Fire Direction Control (specify)

        1. LASER Rangefinder

        2. Periscope

        3. Computer

        4. Other

40. If you had down-time due to maintenance problems of any system was this due to:

    A. Lack of maintenance personnel

    B. Awaiting parts

    C. Awaiting tools

    D. Processing Work-Order requests

41. Which systems required the most maintenance?

    A. Hull

    B. Automotive

    C. Communication system

    D. Armament (specify)

        1. Main gun

        2. Coax

        C. 50 Caliber

    E. Fire Direction Control (specify)

        1. LASER Rangefinder

        2. Periscope

        3. Computer

        4. Other

GUNNERY QUESTIONNAIRE (DH)

Gunner

Name: _____ SSN: _____

Date: _____ Company: _____ Platoon: _____

1. The periscope design and operation is:

	To see	To Reach	Display Size	Operation	Other
A. Very Poor	____	____	____	____	____
B. Inadequate	____	____	____	____	____
C. Borderline	____	____	____	____	____
D. Adequate - some problems	____	____	____	____	____
E. Very Good	____	____	____	____	____

2. The telescope design and operation is:

	To see	To Reach	Display Size	Operation	Other
A. Very Poor	____	____	____	____	____
B. Inadequate	____	____	____	____	____
C. Borderline	____	____	____	____	____
D. Adequate - some problems	____	____	____	____	____
E. Very Good	____	____	____	____	____

3. The job of nulling the cupola (killing its drift) is:

A. Very Difficult

B. Difficult

C. Borderline

D. Adequate - only minor problems

E. Very Easy

4. Once nulled (drift killed) the cupola nulling should be:

   A. Left alone

   B. Checked periodically, infrequently

   C. Checked frequently

   D. Checked when misalignment to target noticed

   E. Checked almost continuously

5. The procedure for finding the designated target is:

   A. Very difficult to perform

   B. Moderately difficult to perform

   C. Borderline - sometimes difficult

   D. Adequate - seldom have problems

   E. Very Good - no problems

6. The procedure for laying gun on the target is:

   A. Always difficult - confusing and/or time consuming

   B. Moderately difficult - usually have problems

   C. Borderline - some problems

   D. Adequate - ok most of the time

   E. Very Good - no problems

7. The target tracking procedure is:

   A. Very difficult

   B. Moderately difficult

   C. Borderline - some problems

   D. Adequate - occasional minor problems

   E. Very easy

8. The job of keeping the missile on target after firing is:

   A. Very difficult

   B. Moderately difficult

   C. Borderline - some problems

   D. Adequate - occasional minor problems

   E. Very easy

9. The things you have to do to prepare for a conventional ammunition engagement:

   A. Too many things to do

   B. Very many - a large number of things to be done in a very short time and/or done very accurately

   C. Borderline - can do them with some difficulty

   D. Adequate - only minor problems

   E. Easiiy done

10. The steps you have to follow for a conventional ammo engagement are:

   A. Too difficult to follow

   B. Difficult to follow - usually make some mistakes

   C. Borderline - some steps need to be improved

   D. Adequate - only minor problems doing the steps

   E. Very Good - the steps assist you in a successful engagement

11. The things you have to do to prepare for a missile engagement:

   A. Too many things to do

   B. Very many - a large number of things to be done in a very short time and/or done very accurately

   C. Borderline - can be done with some difficulty

   D. Adequate - only minor problems

   E. Easily done

12. The steps you have to follow for a missile engagement are:

A. Too difficult to follow

B. Difficult to follow - usually make some mistakes

C. Borderline - some steps need to be improved

D. Adequate - only minor problems doing the steps

E. Very Good - the steps assist you in a successful engagement

13. The arrangement of switches, displays, indicator lamps, circuit breakers, etc. at your tank duty position is:

A. Unacceptable

B. Inadequate - to reach and/or see

C. Borderline - can reach and/or see with some difficulty

D. Adequate - some minor problems to reach and see them

E. Very Good - no problems to reach and see them

14. The room (work space) available at your tank duty position is:

A. Unacceptable - too cramped and/or dangerous

B. Inadequate - cramped and/or sometimes dangerous

C. Borderline - can manage my duties with some difficulty

D. Adequate - some minor work space problems

E. Very Good - no work space problems

15. If a target is detected by one of the crew other than T.C., the procedure for alerting T.C. of the target and its location with respect to the tank is:

A. Non-existent - that crewman merely reports to T.C.

B. Available but inadequate - the procedure must be improved

C. Borderline - the procedure should be improved

D. Available and adequate - some minor problems need improvement

E. Very Good - no problems

16. When selecting a target, how much does the T. C. work with other tanks in the unit to spread the number of targets among the tanks?

A. Never - each tank selects a target independently of the other tanks

B. Occasionally - depending on the tactical situation

C. Usually

D. Whenever possible

E. Always

17. When do you recommend use of the laser range finder?

A. Don't use it

B. Use it when time permits

C. Use it when target has clear outline

D. Use it when range estimation is difficult

E. Always use it when it's working

18. How good is the laser range finder:

A. More trouble than its worth

B. Useful - Difficult and/or its slow to use it

C. Borderline - has some problem

D. Useful in some situations - have to decide when to use it

E. Very good - must be available for best firing results

19. What do you do when the range to the target as estimated by you does not agree with the laser range readout?

A. Reject the laser range and use my estimate

B. Check the laser range if you have plenty of time

C. Always check the laser range

D. Always believe the laser range

E. Range again with the laser by the T.C. or me

20. With a chance to change things in the laser range finder system, show which things must be changed and where changes are desirable. Indicate by an X for each of the following:

	(a) Must Change	(b) Desire Change	(c) No Change
A. Sharing control between TC & Gunner			
B. Steps necessary to get control of laser due to sharing			
C. Rules for deciding when to take control of system			
D. Deciding which range is being displayed			
E. Where your laser readouts are located			
F. Types of switches and controls for system			
G. Where the laser controls are located			
H. How hard is it to decide the range is correct			
I. How difficult is the laser system to operate			
J. Are operating procedures standardized enough			
K. Are you confident enough in laser ranges			
L. How was training for laser range finding			
M. Is there enough time for laser practice			
N. Are there enough safety instructions for laser			

21. What do you do if you suspect a laser range finder malfunction?

A. Rely on visual range estimates using periscope reticle pattern

B. Keep control of the laser ranger and try ranging again

C. Request T. C. to repeat ranging

D. Turn laser ranger Off for a moment then back On

E. Check curcuit breakers

22. Arrange the following things in terms of their importance in the decision of which gun and ammunition to use. Place the things in your preferred order by placing (a) in the blank space of the thing you think is most important, put (b) by the second most important until all the things have a letter in the blank space behind them.

A. Type of target _____

B. Number of potential targets _____

C. Range to target _____

D. Degree of threat to own tank _____

E. Target location _____

F. Deployment of own tanks _____

G. Deployment of enemy forces _____

H. Disposition of ammunition (quantity) _____

23. How was the gunnery training given to you and the crew:

A. Not enough to get us ready for the firing tables

B. Inadequate - with some major problems

C. Borderline - with some problems

D. Adequate - with some minor problems

E. Very Good

24. Show which things in gunnery training need to be changed. Show which ones must be changed, and in which ones change is desirable. Indicate by an X for each of the following:

	(a) Must Change	(b) Can Improve	(c) No Change Required
A. Quantity of training overall			
B. Quantity of dry fire practice			
C. Instruction on individual firing duty procedures			
D. Instruction on crew procedures			
E. Training aids and materials			
F. Training tests and examinations			
G. Retest procedures after failure of Pre-Gunnery Exam			

25. Show which of the things related to time given in gunnery training that need to be changed. Which must be improved, and which can be improved. Indicate by an X for each of the following:

	(a) Must Change	(b) Can Improve	(c) No Change Required
A. Amount of time spent in actual range firing			
B. Amount of time spent in actual firing in simulated combat exercises			
C. Amount of time spent in instruction on tactics			
D. Amount of time on Tables 1-3			
E. Amount of time on Tables 4-5			
F. Amount of time on Tables 6-7			
G. Amount of time on Table 8			
H. Amount of time on refiring			

26. How does tank noise interfere with communications in the tank:

A. Makes communication almost impossible

B. Makes communication difficult

C. Periodically interferes with communication

D. Seldom interferes with communication

E. Does not interfere with communication

27. Is your seat:

A. Extremely uncomfortable

B. Moderately uncomfortable

C. Comfortable some of the time - uncomfortable at intervals

D. Comfortable most of the time

E. Always comfortable

28. Are seat adjustments:

A. Unacceptable - can't adjust it

B. Inadequate - not enough adjustment must be improved

C. Borderline - could be improved

D. Adequate - minor problems

E. Very Good

29. Which of the following items would you say must be changed and which could be improved:

Item	(a) Must Change	(b) Could Improve	(c) No Change Required
Loc tion and/or how it works:			
A. Armament selector switch	____	____	____
B. Hydraulic/stabilization switch	____	____	____
C. Main gun trigger	____	____	____
D. Range button on cadillac handle	____	____	____
E. Cant switch	____	____	____
F. Laser range finder controls	____	____	____
G. Laser range finder displays	____	____	____
H. Turret hull knobs	____	____	____
I. Periscope controls	____	____	____
J. Telescope controls	____	____	____
Procedures involved in:			
K. Target identification	____	____	____
L. Laying on target	____	____	____
M. Target tracking	____	____	____
N. Missile Aiming	____	____	____
O. Communication with other crewmen	____	____	____

30. Do you have difficulty entering and leaving the tank by your hatch:

A. Always great difficulty

B. Always moderate difficulty

C. Borderline

D. Only when wearing heavy clothing or carrying a load

E. Never - always easy

31. How are your jobs for conduct of fire different when the tank is moving as opposed to standing still:

A. Much more difficult

B. Somewhat more difficult

C. Borderline

D. About the same

E. Easier

32. During firing of the main gun, is the internal environment (temperature, humidity, fumes, etc.) of the tank:

A. Almost unbearable

B. Bearable for short periods

C. Uncomfortable

D. No problem

33. Is the ride quality of the tank such that when it moves you are:

A. Usually very uncomfortable

B. Occasionally very uncomfortable

C. Borderline

D. Moderately Comfortable

E. Comfortable

34. Is the location of your radio controls such that it is:

A. Almost inaccessible - sometimes requires some one else to switch channels

B. Difficult to get at some controls - Detracts from other duties

C. Borderline

D. Adequate - with some problems but does not interfere with other duties

E. No problems

35. Are handholds and footholds used during stand-up operation with the tank in motion:

A. Inadequate and/or unsafe

B. Marginal - some major problems

C. Borderline

D. Adequate - only minor problems

E. Excellent - no problems

GUNNERY QUESTIONNAIRE (BG)

Loader

Name: _____ SSN: _____

Date: _____ Company: _____ Platoon: _____

1. The procedures for loading the coax gun are:

   A. Very Poor - Difficult all the time

   B. Poor - usually have some problems

   C. Borderline - sometimes difficult

   D. Adequate - some minor problems

   E. Very Good - no problems

2. The loading and operation of the coax gun due to: (Indicate by an X for each thing below).

	(a)	(b)	(c)	(d)	(e)
A. Its weight is	___	___	___	___	___
B. Length of the rounds is	___	___	___	___	___
C. Location of the chamber is	___	___	___	___	___
D. Way the gun is mounted is	___	___	___	___	___
E. Ammo feed system is	___	___	___	___	___
F. Reloading after stoppage is	___	___	___	___	___

(a) Very Difficult (b) Difficult (c) Borderline (d) Adequate (e) Very Good

3. The things you have to do to prepare for a conventional ammunition engagement:

   A. Too many things to do

   B. Very many - a large number of things to be done in a very short time and/or done very accurately

   C. Borderline - can do them with some difficulty

   D. Adequate - only minor problems

   E. Easily done

4. The steps you have to follow for a conventional ammo engagement are:

A. Too difficult to follow

B. Difficult to follow - usually make some mistakes

C. Borderline - some steps need to be improved

D. Adequate - only minor problems doing the steps

E. Very Good - the steps assist you in a successful engagement

5. How is the room (work space) at your duty station with a full load of ammunition:

A. Unacceptable - too cramped and/or dangerous

B. Inadequate - cramped and/or sometimes dangerous

C. Borderline - can manage my duties with some difficulty

D. Adequate - some minor work space problems

E. Very Good - no work space problems

6. The work needed to peel the barrier bag and load a round into the main gun is:

A. Very great -and tiring

B. Moderate - but difficult

C. Borderline - some problems

D. Adequate - some minor problems

E. Very easy

7. The operation of the breech during loading conventional ammunition in the main gun is:

A. Very difficult and/or very confusing

B. Difficult - difficult and confusing

C. Borderline - usually some problems

D. Adequate - only minor problems

E. Very easy and simple

8. The location and operation of switches, alignment marks, and displays used in loading conventional ammunition is:

   A. Unacceptable - can use only with great difficulty

   B. Inadequate - difficult to reach and/or see

   C. Borderline - some problems to reach and/or see

   D. Adequate - some minor problems

   E. Very Good - no problems

9. The things you have to do to prepare for a missile engagement:

   A. Too many things to do

   B. Very many - a large number of things to be done in a very short time and/or done very accurately

   C. Borderline - can be done with some difficulty

   D. Adequate - only minor problems

   E. Easily done

10. The steps you have to follow for a missile engagement are:

   A. Too difficult to follow

   B. Difficult to follow - usually make some mistakes

   C. Borderline - some steps need to be improved

   D. Adequate - only minor problems doing the steps

   E. Very Good - the steps assist you in a successful engagement

11. The use of the missile checkout panel is:

   A. Unacceptable - too confusing and/or too complex for checkout

   B. Inadequate - confusing and/or complex for checkout

   C. Borderline - checkout can be done with some mistakes

   D. Adequate - needs minor improvement

   E. Very Good - no problems

12. The room (work space) for all jobs available at your tank duty position is:

A. Very Poor - very difficult to perform my required jobs

B. Poor - have problems doing most jobs

C. Borderline - have problems with some jobs

D. Adequate - have problems with very few jobs

E. Very Good - no problems

13. The arrangement of switches, displays, indicator lamps, circuit breakers, etc. at your tank duty position is:

A. Unacceptable

B. Inadequate - to reach and/or see

C. Borderline - can reach and/or see with some difficulty

D. Adequate - some minor problems to reach and see them

E. Very Good - no problems to reach and see them

14. When selecting a target, how much do you work with other tanks in the unit to spread the number of targets among the tanks?

A. Never - each tank selects a target independently of the other tanks

B. Occasionally - depending on the tactical situation

C. Usually

D. Whenever possible

E. Always

15. If a target is detected by one of the crew other than the T.C., the procedure for alerting him of the target and its location with respect to the tank is:

A. Non-existent - that crewman merely reports to T.C.

B. Available but inadequate - the procedure must be improved

C. Borderline - the procedure should be improved

D. Available and adequate - some minor problems need improvement

E. Very Good - no problems

16. Is your seat:

A. Very uncomfortable - can't sit straight

B. Inadequate - moderately uncomfortable

C. Borderline - Comfortable sometimes, uncomfortable once in a while

D. Adequate - Comfortable most of the time

E. Very Good - always comfortable

17. Are seat adjustments:

A. Unacceptable - can't adjust it

B. Inadequate - not enough adjustment must be improved

C. Borderline - could be improved

D. Adequate - minor problems

E. Very Good

18. Do you have difficulty entering and leaving the tank by your hatch:

A. Always great difficulty

B. Always moderate difficulty

C. Borderline

D. Only when wearing heavy clothing or carrying a load

E. Never - always easy

19. How are your jobs for conduct of fire different when the tank is moving as opposed to standing still:

A. Much more difficult

B. Somewhat more difficult

C. Borderline

D. About the same

E. Easier

20. During firing of the main gun, is the internal environment (temperature, humidity, fumes, etc.) of the tank:

A. Almost unbearable

B. Bearable for short periods

C. Uncomfortable

D. No Problem

21. Is the ride quality of the tank such that when it moves you are:

A. Usually very uncomfortable

B. Occasionally very uncomfortable

C. Borderline

D. Moderately Comfortable

E. Comfortable

22. How was the gunnery training given to you and your crew:

A. Not enough to get us ready for firing tables

B. Inadequate - with some minor problems

C. Borderline - with some problems

D. Adequate - with some minor problems

E. Very Good

23. How does tank noise interfere with communications in the tank:

A. Makes communication almost impossible

B. Makes communication difficult

C. Periodically interferes with communications

D. Seldom interferes with communication

E. Does not interfere with communication

24. Show which things in gunnery training need to be changed. Show which ones must be changed, and in which ones change is desirable. Indicate by an X for each of the following:

	(a) Must Change	(b) Can Improve	(c) No Change Required
A. Quantity of training overall			
B. Quantity of dry fire practice			
C. Instruction on individual firing dury procedures			
D. Instruction on crew procedures			
E. Training aids and materials			
F. Training, tests and examinations			
G. Retest procedures after failure of Pre-Gunnery Exam			

25. Show which of the things related to time given in gunnery training that need to be changed. Which must be improved, and which can be improved. Indicate by an X for each of the following:

	(a) Must Change	(b) Can improve	(c) No Chan Requir
A. Amount of time spent in actual range firing			
B. Amount of time spent in actual firing in simulated combat exercises			
C. Amount of time spent in instruction on tactics			
D. Amount of time on Tables 1-3			
E. Amount of time on Tables 4-5			
F. Amount of time on Tables 6-7			
G. Amount of time on Table 8			
H. Amount of time on refiring			

26. Are handholds and footholds used during stand-up operation with the tank in motion:

A. Inadequate and/or unsafe

B. Marginal -some major problems

C. Borderline

D. Adequate - only minor problems

E. Excellent - no problems

27. Is the location of your radio controls such that it is:

A. Almost inaccessible - sometimes requires some one else to switch channels

B. Difficult to get at some controls - Detracts from other duties

C. Borderline

D. Adequate - with some problems but does not interfere with other duties

E. No problems

Driver

Name: _____ SSN: _____

Date: ___ _____ Company: _____ Platoon: _____

1. The arrangement of switches, displays, indicator lamps, circuit breakers, etc. at your tank duty position is:

   A. Unacceptable

   B. Inadequate - to reach and/or see

   C. Borderline - can reach and/or see with some difficulty

   D. Adequate -some minor problems to reach and see them

   E. Very Good - no problems to reach and see them

2. The room (work space) available at your tank duty position:

   A. Unacceptable - too cramped and/or sometimes dangerous

   B. Inadequate - cramped and/or sometimes dangerous

   C. Borderline - can manage my duties with some difficulty

   D. Adequate - some minor work space problems

   E. Very Good - no work space problems

3. How do you like the layout and the way things are arranged for work at your tank duty position?

   A. Very Poor - very difficult to perform my required jobs

   B. Poor - have problems doing most jobs

   C. Borderline - have problem with some jobs

   D. Adequate - have problem with very few jobs

   E. Very Good - no problems

4. How was the gunnery training given to you and your crew:

   A. Not enough to get us ready for firing tables

   B. Inadequate - with some major problems

   C. Borderline - with some problems

   D. Adequate - with some minor problems

   E. Very Good

5. Show which things in gunnery training need to be changed. Show which ones must be changed and in which ones change is desirable. Indicate by an X for each of the following:

	(a) Must Change	(b) Can Improve	(c) No Change Required
A. Quantity of training overall			
B. Quantity of dry fire practice			
C. Instruction on individual firing duty procedures			
D. Instruction on crew procedures			
E. Training aids and materials			
F. Training tests and examinations			
G. Retest procedures after failure of Pre-Gunnery Exam			

6. Show which of the things related to gunnery training that need to be changed. Which must be improved, and which can be improved. Indicate by an X for each of the following:

	(a) Must Change	(b) Can Improve	(c) No Change Required
A. Amount of time spent in actual range firing			
B. Amount of time spent in actual firing in simulated combat exercises			
C. Amount of time spent in instruction on tactics			
D. Amount of time on Tables 1-3			
E. Amount of time on Tables 4-5			
F. Amount of time on Tables 6-7			
G. Amount of time on Table 8			
H. Amount of time on refiring			

7. How does tank noise interfere with communications in the tank:

A. Makes communication almost impossible

B. Makes communication difficult

C. Periodically interferes with communication

D. Seldom interferes with communication

E. Does not interfere with communication

8. Is your seat:

A. Extremely uncomfortable

B. Moderately uncomfortable

C. Comfortable some of the time - uncomfortable at intervals

D. Comfortable most of the time

E. Always comfortable

9. Are seat adjustments:

A. Unacceptable - can't adjust it

B. Inadequate - not enough adjustment must be improved

C. Borderline - could be improved

D. Adequate - minor problems

E. Very Good

10. Do you have difficulty entering and leaving the tank by your hatch:

A. Always great difficulty

B. Always moderate difficulty

C. Borderline

D. Only when wearing heav clothing or carrying a load

E. Never - always easy

11. How are your jobs for conduct of fire different when the tank is moving as opposed to standing still:

A. Much more difficult

B. Somewhat more difficult

C. Borderline

D. About the same

E. Easier

12. During firing of the main gun, is the internal environment (temperature, humidity, fumes, etc.) of the tank:

A. Almost unbearable

B. Bearable for short periods

C. Uncomfortable

D. No problem

13. Is the ride quality of the tank such that when it moves you are:

A. Usually very uncomfortable

B. Occasionally very uncomfortable

C. Borderline

D. Moderately comfortable

E. Comfortable

14. Is the location of your radio controls such that it is:

A. Almost inaccessible - sometimes requires someone else to switch channels

B. Difficult to get at some controls - Detracts from other duties

C. Borderline

D. Adequate - with some problems but does not interfere with other duties

E. No problems

15. Are handholds and footholds used during stand-up operation (head out of hatch) with the tank in motion:

A. Inadequate and/or unsafe

B. Marginal - some major problems

C. Borderline

D. Adequate - only minor problems

E. Excellent - no problems

APPENDIX C

RESULTS OF THE M60A2 TANK COMMANDER'S SEAT ASSEMBLY EVALUATION

TEST OF THE M60A2 TANK COMMANDERS' SEAT ASSEMBLY

Introduction

The purpose of this test was to examine the tank commanders' seat assembly on the M60A2 with regard to operational efficiency and safety. To accomplish this test, two evaluators, one OTEA engineer and one human factors engineer, rode the tank in the gunner's and loader's seats. These personnel noted the standing points, body positions and recorded time spans while the TC performed the motions and issued commands for a conduct-of-fire mission.

The following sections of this report present the methodology for collecting data, the personnel tested, results, conclusions and recommendations.

Methodology

The method used to collect data involved two evaluators riding in the M60A2 tank in the gunner's and loader's seats. A line drawing of the TC's station was used to record foot and body position as the TC performed a conduct-of-fire mission. These data were recorded by the OTEA engineer. Also indicated in these sketches are handholds used by the TC during the test.

The human factors engineer, a contractor from the Essex Corporation, recorded the time spent by the TC from the start of the fire command with the TC in shoulder defilade until he achieved the position to observe the target and lay the gun through the periscope. Upon issuance of the "Cease Fire" command, the time required by the TC to return to chest defilade was recorded. These measurements were taken for both "seat-in" and "seat-out" configurations, allowing each TC to serve as his own control. This eliminates variables due to experience, anthropometrics, preferential techniques, etc. Three (3) data runs were performed on each configuration and times were averaged out. This

precluded confounding of results due to one extremely rapid or one bad trial. The latter might occur randomly and the TC should not be unduly penalized for this factor.

During the trials, the driver, who remained constant throughout the test trials for any given company, was directed to drive a given course, stop upon collection of the desired data for that portion of the trial, turn the tank around and retrace the course for the alternate configuration. Use of the same driver and course, as allowable, reduced variability of results due to driving or course conditions.

Because of the requirement for non-interference with on-going training or duties, it was not possible to use the same course for all companies; however, all subjects in each company were tested on the course suitable to the terrain where training was occurring (e.g., B Company on the practice TCPC course, C Company near the Table IV range, A Company near the Table I, II,III range). Evaluator personnel wore CVC's or headphones and were able to communicate on the tanks' intercommunication system. This allowed them to determine the beginning and termination of each data set. A stopwatch was used to record times.

After each trial run in both configuration, the TC was briefly interviewed with a tape recorder and was requested to fill in a questionnaire related to the TC seat assembly.

Personnel

It was arbitrarily determined that thirty (30) TC's be selected, as available, to perform in the test. This represents over 50 percent (50%) of the TC's in the battalion which number 54 in all. These personnel were acquired on a random, as available, basis during breaks in training periods. The majority of personnel used to perform the actual test were involved in gunnery training at the time of the test; therefore, the techniques for issuing and performing

fire commands were well practiced. Anthropometric information was collected on all personnel through one of the questions on the questionnaire to allow a comparison of height/weight characteristics to task performance. The subjects ranged in height from 63 inches to 77 inches and from 125 pounds to 220 pounds in weight. Table 1 lists the height range of the subjects tested, the number in each increment and the percentage of the test population.

Because of rounding of the percentages, the total indicates slightly higher than 100%. The majority (42%) of these personnel fall in the ranges between 65 and 70 inches height.

Twenty-five percent (25%) of the people in this height range indicated a preference to retain the seat assembly whereas the remaining seventy-five percent (75%) expressed a preference to ride with the seat assembly out. Personnel below 65 inches height responded unanimously to retain the seat. They do not have any other footrests which allow them to ride with any degree of comfort and be able to see outside the hatch.

Two TC's over 70 inches (one at 71 and one at 73 inches) height expressed a preference to retain the seat assembly. These personnel, as determined from the debriefing and questionnaire, had been directed by their battalion to keep the seat assembly in place and had developed a technique which allowed them to perform fire commands satisfactorily. This technique was to simply squat down in the cupola, without moving their feet, and place the eye on the periscope sight. Use of this technique was not limited to these two. Some TC's, when using this "squat-to-sight" approach, extended their knees beyond the safe envelope of the cupola. These subjects were requested to slowly rotate the cupola to see if they encountered interference points inside the tank. When rotating from the centerline toward the right side, many subjects bumped their knees on the grenade launcher control box as the first interference point.

TABLE 1. HEIGHT RANGE OF TC'S IN SEAT ASSEMBLY STUDY

Height (Inches)	No. of Personnel In This Range	% of Population
63	1	3.3
64	1	3.3
65	2	6.6
66	2	6.6
67	2	6.6
68	2	6.6
69	2	6.6
70	2	6.6
71	6	20.0
72	3	10.0
73	5	16.6
74	0	0
75	1	3.3
76	0	0
77	1	3.3
TOTAL	30	99.4

Mean Height = 70 inches Standard Deviation = 3.05 inches

When rotating to the left, the radio jack box protruded into the envelope required by the knees. As long as the direction of engagement of a target did not exceed approximately 30° on either side of the forward tank centerline, there is no interference or safety hazard using the squatting technique.

It was noted that personnel generally employed one of three techniques for dropping into the turret to use the periscope on a target.

First, the shorter TC (65" or less) stands on the seat pan and squats to place the eye on the periscope. He simply stands to return to chest or shoulder defilade. This technique is satisfactory only within the constraints noted above. Some subjects did not extend outside the safe envelope; however, most of those that used this method did exceed the safe envelope and it is conceivable that injury may result if the turret is traversed rapidly.

A second method used by the subjects when the seat assembly is in place is to stand on the seat pan until a target is acquired. Then, he "unloads" his weight from the seat by grasping the hatch opening, allows the seat to spring-load to the vertical position and drops to the main platform which he pre-set to be at his eye level with the periscope. To return to chest or shoulder defilade, he usually stands on the screen guard partially surrounding the main platform with his right foot, places the left foot on the lower left non-adjustable step (or on the personnel heater control box directly below it), and places his right foot on the handle which controls the main platform height and attempts to lower the auxiliary platform with his left foot. When the cupola is rotated away from the front centerline, the screen guard cannot be used since it does not extend far enough. Usually, one of the ammunition storage brackets is used in this case. This will not be possible with a fully loaded tank. Lowering the auxiliary platform and the seat pan can be extremely time consuming in some cases. This is especially true when operating in rougher terrain than used in this test or with muddy or wet boots. Raw

times of 11 and 12 seconds for the subject to return to the chest defilade position using this method were recorded. Further, damage may result to the personnel heater control box because of the stress it receives when being used as a step. The auxiliary platform is spring-loaded to the vertical position. In this configuration, the upper edge of the platform is behind the plane of the seat pan which also spring-loads to the vertical position. To lower the seat pan, the crewman must engage the auxiliary platform with his heel or toe, lower the platform to clear the lip of the seat pan, then engage the seat pan with the other foot and lower both (the pan and the platform) to the horizontal position. Frequently, the auxiliary platform slips free of the foot and retracts; thereby, precluding the deployment of seat pan. A modification had been made to one tank which was used in the study. The return spring which retracts the auxiliary platform seat pan to the vertical position had been removed. This allows the T.C. to easily deploy the seat/platform assembly upon return to shoulder defilade, but it increases the difficulty of dropping to the eye height on the main platform. The auxiliary platform must be manually raised or it will injure the T.C.'s back since it tends to remain in the horizontal position without the retractor springs in place. Another difficulty with this technique is when the T.C. unloads his weight, he typically swings his feet outward to allow clearance for seat and platform retraction. His feet sweep or kick into the loader's compartment. The observer did not escape being kicked several times while exercising extreme caution to do so. A loader who is occupied in performing his duties will not be as alert and could be injured. At the very least, the loader may drop the round he is attempting to load or have it kicked out of his hands. This consumes valuable loading time or results in potentially hazardous damage to the ammunition.

In the third method, the extremely tall subject simply presets the main platform and never uses the seat assembly at all. He simply drops his head to the periscope to view and then stands to achieve shoulder defilade. There was only one subject who was tall enough (77 inches) to perform in this manner.

With the seat removed, all personnel except the 77 inch tall subject stood on the seat frame crossbrace and dropped to the pre-set main platform for use of the periscope. This has proven on several occasions to be hazardous as the feet sometimes slip from the seat crossbrace when operating in rough terrain. In order to return to shoulder defilade, the TC stepped on the main platform screen guard, with his right foot, pulled himself up with a handhold on the hatch opening and stepped on the crossbrace. All personnel except the two shortest TC's (63 inches and 64 inches) could see reasonably well standing on the crossbrace. These two could see off to the sides but reported a blockage of vision by the periscope ballistic shield directly in front of the hatch.

Results

The results of the time trials are shown in Table 2. In Table 2, the first or top row of figures indicates the average time (4.97 seconds) required by the TC's to return to shoulder defilade after laying his gun on the target with the seat IN. The figure in the DOWN column represents the average time (3.73 seconds) spent by the TC'c to drop down to eye level with the periscope after acquiring the target with the seat assembly in IN place. The row labeled OUT represents the average times (1.7 seconds) recorded for the subjects to perform the fire command tasks with the seat assembly OUT. The bottom row of figures represents the difference in average times between the SEAT IN, SEAT OUT conditions. As can be seen, there is a saving in time of 3.24 seconds for

the subjects to return to shoulder defilade with the SEAT OUT and a saving of 1.6 seconds for them to drop inside the turret to lay the gun with the periscope. These savings represent an approximate 65% and 43% quicker reaction time.

TABLE 2. AVERAGE TIMES AND DIFFERENCES FOR TC'S TO ACQUIRE, LAY ON TARGET AND RETURN TO DEFILADE WITH TC SEAT ASSEMBLY IN AND/OR OUT

SEAT	UP	DOWN
In	4.97	3.73
σ	2.7	1.2
Out	1.73	2.13
σ	0.64	0.65
TIME DIFFERENCE - - - - - - - - - - -	3.24	1.60

From these data the 99th percent probability times were compiled. These times are the times expected in ninety-nine percent (99%) of TC operations, based on the results of this sample. For the UP operation, the 99th percent times are: SEAT IN - 6.24 seconds; SEAT OUT - 2.03 seconds. This means that, based on the test data, in 99 of 100 times that the TC performs operations requiring him to move up, the maximum time expected is 6.24 seconds with the seat in, and 2.03 seconds with the seat out, for a difference of 4.21 seconds.

With the down operation the 99th percent limits on time to perform are 4.30 seconds with the seat in, and 2.44 seconds with the seat out. The difference is 1.86 seconds.

The individual difference in time saving ranged from 0.1 seconds to 10.0 seconds to return to shoulder defilade with the seat out and from 0.3 seconds to 5.8 seconds for the subject to lay his gun with the periscope. In those cases where very small time differentials were recorded, it was noted that the technique to lay on target and/or return to shoulder defilade was almost immaterial to the seat configuration. These personnel utilized the technique of squatting to use the periscope regardless of whether they were standing in the seat pan or on the seat frame crossbrace.

The data sheets were reviewed to determine the number of operations or movements the TC makes during the conduct-of-fire mission. This included the total number of operations to sight the periscope and return to shoulder defilade. It was found that the TC's utilized a total of 142 movements to perform the fire mission with the seat in and only 110 with the seat out. This is an average saving of one (1) movement per mission or twenty-three percent (23%) with the seat out.

It should be mentioned here that the subject, while operating with the seat in and not using the squatting technique, is forced to stand at an angle when he uses the main platform to achieve an eye level position at the periscope. This angle was measured from the center of the hatch opening (as measured from both fore-aft and laterally) to the center of the main platform and found to be 6° with a backslope (i.e., feet forward, head toward rear). The center of the hatch opening was established and a plumb line was attached to a flag stick at the hatch center point. This plumb line was drawn taut

and held at the measured center of the main platform. The angle was measured with a protractor at the hatch opening. This means that a crewman riding on the main platform of a M60A2 tank with the seat assembly in must stand at a negative 6° angle. Many (approximately 90%) of the subjects interviewed stated that this position becomes uncomfortable after a period of time. With the seat out, the subject can assume a more nearly vertical standing position and does not become uncomfortable as quickly.

When a subject operates with the seat out and is too short to stand on the raised main platform, he usually stands on the seat frame crossbrace. These personnel have reported that after riding for an extended period of time with the instep hooked over the brace, the legs and back become extremely tired. Also, several instances were recorded during AIT training where TC's feet were thrown clear of the foot rest. These personnel bumped the hatch with the chest or arms and required medical treatment.

Finally, a number of subjects stated during the trial runs that the seat should be removed; however, on the questionnaires, these personnel wrote that the seat should be removed for tank gunnery and on tank trails and should be retained for cross-country exercises. Many TC's stated that they now use the seat only because it is battalion policy. It should be pointed out that the preliminary analyses of this study resulted in a battalion policy decision that the use or non-use of the seat for tank gunnery was left to the discretion of the individual tank commanders.

Approximately 44% of the subjects who responded to the questionnaires served in three (3) or four (4) other types of tanks. Also, sixteen percent (16%) served in one other type, 16% in two, 10% in five, 10% in six, 4% in seven and one member served in nine types of tanks other than the M60A2. All

these personnel who had served in the M60A1 reported that they would prefer a seat similar to that in the M60A1 which could rapidly be displaced for a fire mission while providing a comfortable seat on a march or while performing standard operations.

Conclusions/Recommendations

The recorded data demonstrates that the crewman can operate faster and more efficiently when the TC's seat assembly is removed. When one considers that the non-penalty "opening time" for a 50 caliber engagement on the M60A2 during Tank Gunnery is 15 seconds, and the TC spends almost 2 seconds more with the seat in than out to drop into the tank to use the periscope, this seems excessive. The TC reduces the time to achieve periscope height by 11% when the seat is out. In the time required to resume shoulder defilade, there is an expected saving of 4.21 seconds (99th percent). During tank gunnery where targets are spaced sufficiently far apart, this is not critical. In combat, this could mean the difference between firing a round or not.

These data must also be tempered by the knowledge that the shorter TC's cannot operate satisfactorily without the seat assembly installed or something similar. The data overwhelmingly favor discarding the seat assembly for certain missions and retaining it for others. This leads to the conclusion that the seat assembly and the entire TC station be reviewed, and modifications be considered. One suggested modification being the adoption of a seating device which would be universally acceptable to TC's of a wide variety of height and be compatible with the functions of a TC during tank gunnery. Also, the modification should provide some means for the TC, regardless of anthropometrics, to be moderately comfortable during extended road marches, cross-country travel and gunnery exercises.

It is not in the province of this test report to make specific design

recommendations; however, consideration should be given to the use of a seat similar to that used in the M60A1. Also, some means should be found to elevate the short TC in a M60A2 from the seat frame crossbrace to allow him to adequately see outside the tank while traveling if the seat assembly is not available. This modification, if performed, must allow consideration of safe and rapid ingress/egress from the tank for all crewmembers while still satisfying the requirements of a tank mission.

Summary

The purpose of this summary is to indicate these safety related items which must be considered.

1. TC's who use the "squat-to-sight" technique may exceed the safe envelope of the cupola if the cupola is rotated more than 30° either side of the tank forward centerline.

2. The potential hazard to personnel or hardware when the TC unloads his weight from the seat pan to hop into the turret to use the periscope. This hazard results from the sweeping or kicking-out motion of the TC's feet to allow the seat pan and auxiliary platform to spring-load to the vertical position.

3. There have been several occasions recorded where the TC's feet, with dry boots, have slipped from the improvised, unrestrained foot-rest, such as the seat frame crossbrace, in rough terrain. Injury resulted to some TC's from striking the hatch opening or falling inside the turret.

APPENDIX D

FULL COMBAT LOAD M60A2 TEST

AFMAS-GC-PE 5 November 1973

MEMORANDUM FOR RECORD

SUBJECT: Proposed Evaluation of Fully Loaded M60A2 Tanks

1. General. The purpose of this paper is to present a methodology for evaluating combat loaded M60A2 Tanks and the data that may result.

2. Methodology. The methodology shown in inclosure 1 is based on the data required by the essential elements of analysis shown in inclosure 2. Inclosure 3 is a request from the Human Factors Evaluators to obtain a crew space evaluation.

3. Anticipated Results.

a. Human engineering factors to include crew space, crew size, field operating conditions, refuel, rearm procedures.

b. The extra weight carried by the tanks may produce additional RAM data. M60A1/A2 common maintenance problem areas may surface due to additional weight. The weight differential between net and combat load is approximately four tons.

c. Procedures and times used by the transportation section of the battalion support platoon will be observed and recorded.

d. All physiological and psychological effects upon the crew will be documented.

4. Personnel and Equipment.

a. The 1/67 Armor Bn has the following dummy ammunition on hand:

(1) 300 ea 152mm.

(2) 130 ea Shillelagh Missiles

(3) 39,000 rounds + 7.62mm.

(4) 3,600 rounds .45 cal.

(5) 0 .50 Cal.

b. The 1/67 Armor Bn has the balance of the items on hand to combat load two platoons of tanks.

c. The two ARI Human Factors Evaluators will observe one platoon each and record all significant data on crew positions and human factors.

d. Each company evaluator will record and evaluate specific areas.

e. The maintenance evaluaton team will observe and evaluate problem areas that may result due to the additional weight (RAM Data).

f. The battalion evaluator's areas of interest are shown on inclosure 5.

g. Crew questionnaires

h. All data related to combat loaded M60A2 Tanks will be forwarded thru Data Collection to the Objective Three Writer.

5. Period of Test: The two platoons should be loaded 50 percent on Tuesday, 13 Nov., the first week of phase III. These platoons will be from the same tank company of the 1/67 Armor. Two different platoons may be loaded the 26th through the 29th of November and 10-13 December.

Exercise Guidelines
M60A2 ICTT FTX/ATT

1. Exercise guidelines will be established to insure that essential elements of analysis are evaluated/observed during the November FTX/ATT.

2. The following guidelines pertain to the M60A2 Tank Company upon attachment to the Mechanized Infantry Battalion:

a. All Tank Company maintenance and parts requests will be forwarded through the Mech Infantry Battalion trains.

b. The detached M60A2 Tank Company must establish and maintain a Prescribed Load List of repair parts. This PLL will be established by the parent unit prior to detachment.

c. The 1/67 Armor Battalion will provide GOER fuel and cargo (ammo) support to the detached tank company as company trains.

d. The detached tank company will not receive logistic support from the 1/67 Armor Battalion unless specifically requested through the mechanized infantry battalion.

3. The following guidelines apply to the mechanized infantry battalion:

a. The mech infantry battalion maintenance platoon will assist the M60A2 tank company with repair and technical assistance.

b. All assistance requested that cannot be accomplished within the mech infantry battalion maintenance platoon will be requested from the common field trains.

c. All maintenance and parts assistance will be logged by the mech infantry bn maint platoon.

d. The mech infantry bn will provide fuel and cargo support to the detached mech infantry company.

e. The mech infantry bn CO should be made aware of the characteristics and support requirements of the M60A2 tank company prior to attachment.

4. The following guidelines apply to the 1/67 Armor Battalion:

a. The 1/67 Armor Battalion maintenance platoon will maintain a record of all maintenance assistance and repairs furnished the attached mech infantry company.

b. The detached M60A2 tank company should be at least eighty percent operable strength at the time of attachment to the mech infantry battalion.

5. The following general guidelines will be provided:

a. All commanders involved will be briefed concerning tactical concepts associated with the FTX/ATT.

b. Command and control procedures will be observed and reported.

NAME: Angelo J. Micocci DATE: 3318

EVALUATOR COMMENTS

During the course of this test, things may become apparent to you which should be recorded and passed on to the test HQ, but are not covered on any forms. Please use this form to record this information. Be as complete and specific as possible; include names of individuals, dates, units, bumper numbers, etc. As an aid, a list of objectives of the test is printed on the reverse side.

On this date, I participated in the Combat-load test of the M60A2. This included riding in the gunner's compartment on a road march with 50% load and helping load to 100% at an assembly area. My evaluation included assessing the reach to the various controls and displays in this station. Following is a listing of the findings during this test.

1. A number of crews were found not to know how to sequence loading of the A-2 during the initial (50%) loading. This was found to be true during loading at the assembly area. The T.C. loaded 6 missiles first, then the conv. ammo. In order to install these rounds, three missiles had to be removed, the ammo rack bases removed and the conv. rounds loaded in the racks to the right of and below the main gun. This indicates a need for a specific sequence and this needs to be practiced.
2. Inclusion of the full load did not significantly alter operating capability in the gunner's station. This station is cramped before the tank is loaded and the ammo did not make a great deal of difference.

3. The loader will be cramped and operations somewhat more difficult with the reduced space available for movement.

4. Exposed hex-head bolts (telescope mount and cable clamps) rub the left-knee and create a very uncomfortable condition. Either these should be padded or the gunner issued a knee-pad of some sort.

5. This author (5'11½" - 182#) had no trouble reaching critical controls. Use of the periscope requires leaning slightly forward and to the right. This might be uncomfortable after extended periods.

6. Use of the manual elevation device requires re-positioning of the left leg but is feasible.

7. The gunner's seat backrest fit comfortably. Shorter or taller personnel might be hindered by the backrest not fitting the lumbar region of the back as well.

8. Inclusion of the full combat load did not appear to affect mobility of the A-2 significantly; however, this author is not an expert in this field and the reader should be tempered by this thought.

9. At one point during the road march (on bumpy terrain), the gunner's hatch sprung loose from its restraint with the manual travel lock level in place. I happened to be holding onto the hatch and prevented it from slamming shut by that means. The manual latch lever was then disengaged and the hatch repositioned open and the lever snapped back into the clip. The hatch held after that. This aspect (slipping loose from the open position) should be investigated to preclude injury to the gunner.

APPENDIX E

DRIVER SAFETY STUDY

REPORT ON M60A2 DRIVER STUDY

Introduction

On 28 November 1973, a driver of Alpha Company, 1st Battalion 67th Armor suffered lacerations of the face and cheekbones broken in two places. The lacerations required 16 sutures to close. This occurred when the T.C. announced to the crew that he was going to rotate the turret and the driver did not lower his seat to protect his head. A scissors effect trapped his head between the gun tube ballistic shield and the driver's hatch. This was the second such reported incident with the first not resulting in serious injury. In the first accident, the driver was merely bent over double by the weather cover bolts on the ballistic shield and was able to report for duty the following day. History indicates that a driver at Fort Knox, Kentucky, had his rib cage injured during a similar accident and subsequently died from complications (i.e., pneumonia). Nine instances have been recorded of traverse gear box failures and/or mechanical locks failing due to gun tube encounters with trees or the action of inertial forces. Any of these incidents could have resulted in serious injury to a driver not maintaining clearance between his head and the ballistic shield.

In addition, several drivers were in the vicinity of the tank where the safety evaluation was progressing and indicated that on several occasions each of them had experienced "close calls" when the ballistic shield passed over their heads during turret traverse. One driver reported that he was partially lifted out of the driver's compartment during one of these maneuvers. It is not known how many of these incidents occurred; however, it is apparent

that a safety problem exists and must be corrected. If it is not, serious injuries may be expected during the combat life of the tank.

Methodology

A meeting was held on 5 December 1973 which was attended by representatives from the MASSTER Company evaluators, Chrysler, OTEA, MASSTER Plans and Evaluation Branch, U.S. Army, Europe and Human Factors. The problem area was discussed historically and comments solicited from personnel in attendance. After a series of suggestions were reviewed, personnel in attendance visited the 1/67 motor pool where a Bravo Company tank was made available for study. Measurements were taken at the driver's compartment with the fully depressed gun tube over the edge of the hatch and then directly over the centerline of the hatch. Maximum clearance measured at these points was eight inches from the hatch horizontal plane to the lowest interference point of gun tube ballistic shield. At this point, a driver's field of view was measured and the driver could see a point approximately 20-25 feet in front of the tank. A vehicle moving at 15 mph will travel approximately 22 feet in one second.

With visibility of the ground 20-25 feet in front of the tank the driver should be able to see an obstruction or ditch in plenty of time to slow down. Anything closer than that will be unavoidable in any case since the braking requirements of the M60A2 are to be able to stop the tank within 60 feet at a speed of 20 mph. This negates the opinion of some drivers that he should be far enough out of the hatch to see a point directly in front of the tank.

During gunnery, the driver must operate in a "buttoned-up" mode and the danger of scissoring the crewmen is eliminated.

Results

Many alternatives were discussed including training, emphasis of safety, physical restraints and electrical/mechanical interlocks to preclude vehicle operation while the driver's hatch is open. Training and emphasis of safety have proven not to be effective in reducing injury. Requirements for a crew report are not necessary since the T.C. assumes that all crew members are clear when he announces that the vehicle is being placed in stabilization, target designate, turret power "ON" and/or turret rotation and no crew member replies that he is not ready (safe). In the initial case reported herein, the driver never stated that he was too high out of his station. Also, this would not preclude injury in the event of a runaway turret due to a damaged mechanical lock or gear box failure. Mechanical/electrical interlocks can be overridden by a resourceful driver and did not appear to be the optimum solution. Also, driver discomfort due to driving all the time buttoned-up had to be considered. This left only the physical restraint as a position preventive of injury. The most feasible concept involved the use of a device which would prevent the driver from getting his head too high out of the hatch and suffering consequent injury. It was decided that this device could take the shape of a cage and/or roll-bar to prevent the driver from sitting too high in his station. Pieces of scrap metal were obtained and bent into various shapes to fit over the driver's hatch and under the fully depressed tube as it rotated over the driver's station. This prevented the driver's head from extending high enough to be hit by the rotating ballistic shield. The device must also allow the driver's hatch to slide into position for answering the buttoned-up mode. Such a design was discovered and found to allow ready hatch closing and opening, allow the driver to see approximately 25 feet in front of the tank and keep the head

in a safe posture.

Conclusions and Recommendations

It is concluded that training and safety emphasis are not sufficient to prevent injury. Company commanders and their troops both report, during informal discussions, that safety training and emphasis on training has been religiously imposed and kept current. Supervisors from T.C.'s, platoon sargeants, leaders and company commanders are always vigilant for errors which could lead to safety problems. However, injuries have occurred.

With no specific requirements for crew reports, the T.C. and/or gunner are not aware that there is a safety problem. Further, crew reports that everyone is in a safe posture have also resulted in injuries as shown by the first case indicated in this report.

Interviews with personnel in the immediate area of the test also emphasized a point that the safety evaluation committee surmized and discussed. That being the circumventing of mechanical/electrical interlock devices. Further, partial or total disablement of the vehicle through independent failure of the interlock is not desirable. Fail-safe and/or override systems become complex and present their own reliability/maintainability problems.

Electrical interruption systems such as used on the rear deck are not feasible because of the requirement to disable these when the main gun must be depressed to fire over the front of the tank. These electrical interruption systems elevate the gun systems to preclude firing the guns into the rear deck and disabling the tank. Since the doctrine of tactics states that the M60A2 should engage targets from the front where the A2 profile affords maximum protection, front interruptors would require override or other disabling methods.

Since the other techniques discussed presented additional problems, it was

decided to place emphasis on the physical restraint solution. Toward this end, a series of mockups were constructed and tested empirically on a M60A2 tank in the motor pool. One member of the evaluation team served as the driver (stationary tank) with a tank crew member on hand to rotate the turret as directed. This approach enabled the evaluators to test the geometry of the device and locate potential hinge points. It also enabled the measurement of driver field of view and assured that the clearance were adequate to provide protection.

The geometry of the protective device was of a roll bar type with a radius from the vertical braces equal to the contour of the front edge of the driver's hatch. The hinge points occur at the outside edges of the extreme rubber bumpers on the front edge. This roll bar would detent in place when raised or lowered to prevent accidental dislodging or movement from vibration. When folded to close the hatch, the bar would fit inside the front edge of the hatch against the rubber bumpers. The only reduction of the ingress/egress diameter would be the thickness of the material used. When the tank is to be operated with the hatch open, the driver simply pushes the bar up until it detents or locks in position. To close the hatch, he simply pulls forward on the bar until it locks in the down position and slides the hatch shut. The bar depth or diameter will be sufficient to prevent the driver's head from slipping between it and the hatch.